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NOTES
ON
MILITARY TELEGRAPH INSTRUMENTS,
WITH
DIAGRAMS OF CONNECTIONS,
BY
MAJOR H. F. TURNER, R.E.

REVISED EDITION.

LONDON:

Printed under the Superintendence of Her Majesty's Stationery Office,

AND SOLD BY

W. CLOWES & SONS, Limited, 13, Charing Cross; HARRISON & SONS, 59, Pall Mall; W. H. ALLEN & Co., 13, Waterloo Place;
W. MITCHELL, 39, Charing Cross; LONGMANS & Co., Paternoster Row; TRÜBNER & Co., 57 & 59, Ludgate Hill;
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and E. PONSONBY, Grafton Street, Dublin.

1885.



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2328

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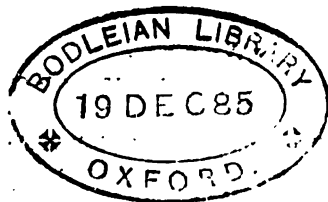
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1885.

Price One Shilling and Sixpence.

1361 (F. 2) 2.720

H.R.H. The Field-Marshal Commanding-in-Chief, in ⁴⁰¹⁸⁵₁₂₃₃, approves of the introduction into the Service of Major Turner's book of diagrams of Connections of Military Telegraph Instruments.



(Wt. 447, 1000 | 6 | 85. H & S 2257)

HORSE GUARDS,
1st May, 1884.

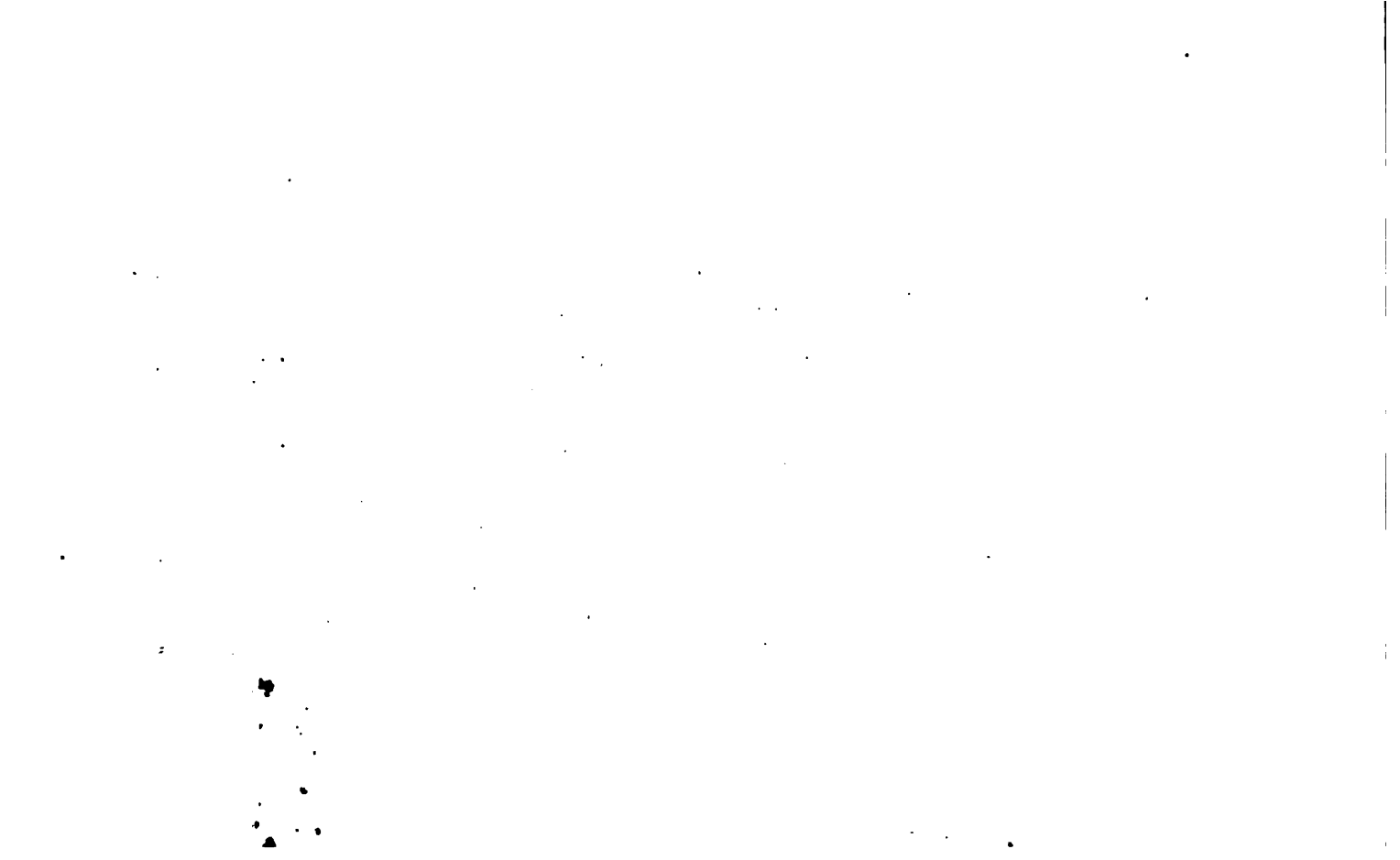
THE Telegraph Battalion, Royal Engineers, is now equipped with sensitive and costly telegraphic apparatus, of the most improved modern design, suitable, if skilfully utilized, for any service that can be required.

In order that these instruments may be used to the best advantage, and that communication may be efficiently kept up in the field under all circumstances, it is essential that the officers and men of the Telegraph Battalion should be thoroughly familiar both with the internal construction of their apparatus and with the methods of combining them to suit the varying conditions which may occur.

This book has been prepared with the view of affording information upon such points, and upon the systems which have been found most effective in actual practice, and His Royal Highness the Field-Marshal Commanding-in-Chief desires that the officers and non-commissioned officers of the Telegraph Battalion, Royal Engineers, will make themselves thoroughly acquainted with its contents, and that the men may be constantly instructed and practised in the methods of working therein shown.

Some of the plates are descriptive of instruments in use on permanent telegraphs at military stations and not included in the field equipment.

WOLSELEY,
A.-G.



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NOTES ON MILITARY TELEGRAPH INSTRUMENTS,

WITH
DIAGRAMS OF CONNECTIONS.

BY
MAJOR H. F. TURNER, R.E.

MILITARY TELEGRAPHS.

THE ARRANGEMENT OF CIRCUITS.

In Telegraphy, as in a railway system, the means of communication consist of main lines and branch lines, with stations of various classes.

The term "Telegraph Circuit" includes any one *unbroken* length of wire, whether it is underground, overhead, covered, or submarine, or in any or all of these positions, the instruments in connection with it, the working battery, and the earths at the terminals.

One end of the circuit is termed "Up," the other "Down;" the base or Head-Quarters would usually be the up extremity, but this must be determined authoritatively at the outset, and when once decided must on no account be altered without instructions, and advices being sent to all concerned.

The rule is that every station sends a copper or positive current to the down line, and a zinc or negative current to the up line; thus the terminal marked L of recorders and sounders is that to which the down line is attached.

Circuits are divided into three classes :—

- (a.) Through circuits.
- (b.) Omnibus circuits.
- (c.) Branch circuits.

A "Through" circuit connects two important offices without having instruments in circuit at any intermediate stations.

An "Omnibus" circuit similarly connects two principal stations, but has intermediate instruments in connection with it.

These two classes of circuits form the main streams of communication.

A "Branch" circuit connects outlying offices with one of those on a principal circuit, the latter is then termed the "Transmitting Office," because messages to and from the branch circuits are there read off and transmitted.

The description of the apparatus to be employed on any circuit must be determined with regard to the operating staff available, the mechanical condition of the circuit, its electrical condition, and the traffic anticipated: thus, for instance, although heavy traffic might be expected, the condition of a line might prevent the adoption of the most rapid apparatus, although the most skilful operators might be available.

When once decided upon, the arrangement of a circuit, its length, the instruments in connection with it, the extremity of it to be termed "up," the points of translation, the hours during which the offices are open, &c., must on no account be altered without authority from the Direction and without previous notice being sent to all concerned.

The combinations of apparatus available in the F.S. Equipment are—

Sounders	}	Worked with relays and local batteries, simplex or duplex, by <i>single</i> and <i>double</i> current.
Recorders		
Sounders	}	Worked without relays, either by intermittent or by continuous current.
Recorders		

The Recorder may also be worked duplex without a Relay.

Vibrators and Telephones.

Telephones.

Translators.

The term "Simplex" is used to describe the system of Telegraphy in which the messages can only be sent in one direction at a time,

"Duplex" denotes the method by which they may be sent simultaneously from each end of the same circuit.

As a rule the principal Through circuits should be worked with relays and sounders duplexed.

The Duplex system requires a wire, the insulation resistance of which varies little from time to time.

Relays are suitable for imperfectly insulated circuits, and for lines exceeding 50 miles in length.

Duplex circuits must never have intermediate stations upon them, except under well understood unavoidable conditions, when special rules for reverting to simplex working during stated hours must be laid down.

With simplex working the number of intermediate instruments should be limited to one when working by direct current (i.e., without relays) and to three when working with relays and local batteries; when the continuous current system is adopted the number of intermediate instruments may be greater.

For lines exceeding 100 miles in length, for badly insulated circuits, and those with intermediate offices the *double current* system is by far the most suitable—it is employed in the Post Office in preference to any other without translation up to 300 miles on good wires, and for all duplex circuits exceeding 25 miles. *Plates 19 and 20* show a method of working in this manner with single current keys and switches; it however requires double battery power.

Continuous Current working exhausts Leclanché batteries, injures the insulation of covered wires, and facilitates the "tapping" of the circuit by an enemy.

It should therefore only be resorted to under the following circumstances, namely:—

- (1.) When it is required to string a number of intermediate instruments upon a wire.*
- (2.) For long and badly insulated circuits, when relays and local batteries are not available.
- (3.) When it is required to keep up communication with an office which is on the move, or to which battery cells cannot easily be sent.

The effect of a leak on a continuous current circuit may often be counteracted by dividing the battery power instead of having it concentrated at one terminal station.

Should the armatures of instruments working by direct current, whether intermittent or continuous,

* As many as twenty-five instruments have been worked in America by this method on one wire.

be found to stick, owing to the residual magnetism of the cores of the magnets, and the difficulty cannot be overcome by adjustment, it may often be got over by reversing the poles of all the batteries.

When it decided to work permanently on the continuous current system it is desirable to procure Daniell batteries if possible.

When a pressure of work is expected on a Branch circuit, it may be joined to one of the Through circuits, to save the labour and delay of transmission; the Branch circuit thus forming a prolongation of the Through circuit, one of the terminal instruments becoming intermediate, and the other being cut out. If authority is given thus to connect a Branch with a Through circuit at some intermediate point of the latter, it will be necessary to cut the Through circuit at the point of connection, and an instrument must then be fixed upon its disconnected end to keep up communication; but as before stated such arrangements must never be made without authority. It is essential that the apparatus on the Branch should be similar to that on the Through circuit, and that sufficient battery power should be provided.

If the Branch circuit is one of a temporary kind, and therefore more liable to interruption than the main line, risk of delay is incurred by making a connection except by means of a complete translator, *vide* pages 18 and 19, and *Plates* 23, 24, and 25.

The number of cells required for a circuit depends upon so many conditions that it is impossible to lay down a rule which shall be applicable to all cases.

A current of 15 milliamperes should usually be provided, or double that to produce a loud sound when working direct current sounders; this may be calculated by the formula—

$$\text{Current in milliamperes} = \frac{\text{E.M.F in Volts} \times 1000}{\text{Total resistance in Ohms}}$$

The P.O. rule is to allow 15 to 20 milliamperes for direct writing circuits and 14 to 17 for double current.

When the insulation of a Through S.C. circuit becomes generally defective, or when the length is great, Translators* may be introduced at intervals; several methods of joining up Translators are given in the diagram, and the peculiarities of each are described in the notes at pages 18 and 19.

* The Translators shown are all for S.C. circuits.

The equipment provides a means of temporarily re-establishing communication in case the line is interrupted by earth faults which prevent any of the ordinary Telegraph instruments being worked.

Vibrators and Telephones should then be substituted for the ordinary apparatus, as shown at *Plate 26*.

This method will often enable communication to be maintained long after other methods fail. It can also be employed with advantage when the condition of the line and strength of the received currents are liable to considerable variation, as in this method the receiving instrument never requires adjustment for any strength of current. On the other hand, this system should never be employed where there is any chance of interference from inductive action, as where several lines are run on the same poles for considerable distances. When two or more circuits worked on the vibrating system terminate in one office, a separate *earth* connection should be provided for each, the earth plates being sunk at least 10 yards apart.

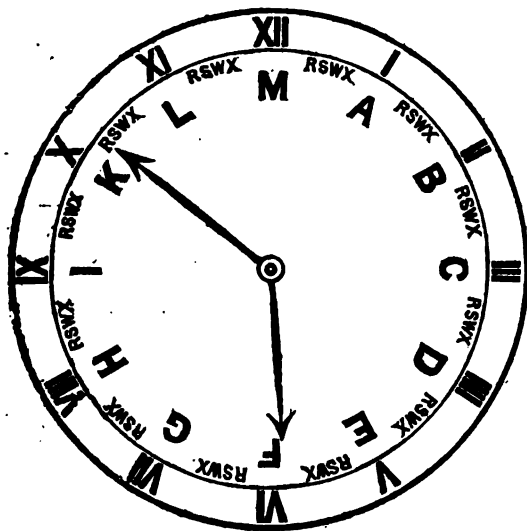
This novel and valuable system has been successfully worked under the following circumstances:—

(1.) A bare wire was laid along the ground beside a railway for 16 miles, it was in contact with railway stay wires and covered with a pile of rails; Vibrators and Telephones were put in circuit and worked well.

(2.) Vibrators and Telephones were joined to an ordinary Telegraph wire at places 70 miles apart and worked well with five cells.

(3.) Two wires were fitted with ordinary recorders so as to form two separate circuits, about 25 miles in length, from New Cross to Chatham; between the two circuits at each station was then placed a Vibrator with its Telephone and a Condenser, and communication was carried on independently thereby, while the Recorders were being worked; thus the two circuits were made to do the work of three. Ten cells were used. The plates of the Condensers prevented the two lines from being in contact with one another through the coils of the Vibrator and the connecting wires. The connections were as shown on *Plate 26*, except that Terminal D of the Vibrator was joined to one of the circuits, and Terminal U through the Telephone to one terminal of the condenser, the other terminal of which was connected to the second working line.

TIME SIGNALS.



If the letters be used singly they show the hours only.

If they be used in combination they show the hours, and some number of periods of five minutes in addition to the hour.

Thus, M by itself denotes 12 h., and M A denotes 12 h. 5m.; A by itself denotes 1, and A A denotes 1 h. 5 m.; C by itself denotes 3 h., and C H 3 h. 40 m.

In order to denote the four intermediate minutes in every complete period of five minutes, the letters R, S, W, X are employed, R denoting the first, S the second, W the third, and X the fourth minute after each hour or after each complete period of five minutes.

The *fore* and *afternoon* will be invariably identified by the letters A.M. and P.M. respectively following "the code."

In order to avoid the difficulty of distinguishing between *midnight* and *noon* (both being represented by the letter M), messages will never be "coded" M; but if handed in either exactly at midnight or exactly at noon, they will be coded MB AM, or MB PM, as the case may be.

Time 5 h. 52m. a.m.

Signal { E K S A M
 — — — — —

AUTHORISED ABBREVIATIONS.

C.Q.	All stations.	N.N.	Nothing more coming.
D.F.	Direct line free.	R.D.	Signal of acknowledgment.
G.	Go on.	R.Q.	Repetition or correction required.
G.Q.	Fresh line.	R.R.	Words to be in inverted commas.
I.I.	Break signal between the addresses and the body of the telegram.	T.I.	Daily time signal.
I.Q.	Not through.	T.Q.	Am I through.
K.K.	Words to be in parenthesis.	U.Q.	Attend to other instrument.
K.Q.	Say when you are ready.	V.E.	(- - - - -) completion of message and "understand" signal on the printer.
L.L.	Words to be underlined.	Y.Q.	Two or more stations.
M.E.	Mean time.	Z.M.	Weather.
M.Q.	Wait.	Z.Q.	Attend to switch.
H.Q.	How are signals.		

All abbreviations in the text of messages are strictly forbidden. Telegrams must be invariably signalled letter for letter as written by the sender. In the case of news messages for the press, however, this rule does not apply.

NOTES ON INSTRUMENTS IN USE IN MILITARY TELEGRAPHY.

INSTRUMENT, TELEGRAPH, MORSE RECORDING, UNIVERSAL PATTERN, MARK I.

The electro-magnet of this instrument consists of one coil of 550 ohms resistance, wound upon two bobbins; *Plates 7 and 8* show the ends of the coil are attached to brass blocks, so that by removing the screws between them the coils *12, Mark 1*, can be separated from the rest of the instrument and worked by relay and local battery; this arrangement is shown in *Plate 12*. inker working by relay.

Working as a relay. The instrument itself may be used as a relay or to ring a bell, by connecting wires to screws *b b*, *Plates 1 and 2*. The connections for working are shown in *Plates 7 and 12*.

Galvanometer. The resistance of the galvanometer is about 130 ohms.

Caution. Care must be taken to detach and empty the ink-well when about to move; also not to screw too far the screw *n*, *Plate 2*, to which the armature spring is attached: should this be done, and the bar holding the armature spring *w*, *Plate 2*, forced up so high that it will not return to its place, take out screw *m* and remove *n*, turn the bar round until the groove cut along it coincides with a projecting guide-pin inside the spring case *o*, it can then be easily slid down again into position.

To increase speed. To increase the speed—take out screws *d d*, *Plates 1 and 2*, slide out the cover and end of case, and compress the spiral spring, which restrains the fan of the regulator.

The instrument is furnished with a plate lightning protector, which is imperfect, as there is no earth connection when the instrument is at an intermediate station. Care must be taken that a paraffined paper is placed between the plates: it should project $\frac{1}{4}$ inch at least all round beyond them.

This instrument is now superseded by an improved pattern, sealed as—"Instrument, Telegraph, Morse Recording, Universal Pattern, Mark II."

INSTRUMENT, TELEGRAPH, MORSE RECORDING, UNIVERSAL PATTERN, MARK II.

Electro-magnet. The electro-magnet of this instrument has 2 coils, each of 150 ohms exactly; the two wires are wound on side by side, commencing at the centre of each bobbin, thus there are no "inside ends;" and if the projecting ends of the wires happen to get broken off short, it is only necessary to take off the coils, as hereafter described, and to unwind a turn of wire to repair the damage; the ends of one coil are attached to the brass blocks *D* and *U*, and of the other to $\textcircled{D}$ and $\textcircled{U}$, *Plates 1 and 2*. The coils are wound so that a current flowing through one coil and entering at *D*, will produce a similar effect upon the cores to that caused by a current entering at $\textcircled{D}$ and flowing to $\textcircled{U}$. The coils may be connected by placing both the links *s s*, *Plates 1 and 2*, between the blocks $\textcircled{D}$ and *U*, when the full resistance of 300 ohms will be in circuit; they are then said to be joined "in series." If one link is placed so as to connect block *D* to $\textcircled{D}$, and the other to connect block *U*

to $\odot$, the coils are said to be joined for "quantity," and their combined resistance is then only 75 ohms, or $\frac{1}{2}$ of the total resistance. This is the arrangement shown in *Plates 1 and 2*. The first method should be adopted, as a rule, when the inker is joined to the main line circuit, and the second when it is worked by a relay and local battery.

The coils may be disconnected from the switch, &c., by removing screws r^1 and r^2 ; this is done for the purpose of working the instrument by a relay. In the diagrams the proper method of manipulating the links and screws between the blocks is shown for each arrangement, and must be always carefully attended to. When the screws are to be inserted, the blocks are shown connected by black spots representing the screw heads; when it is intended that the screws are to be removed, the blocks are shown separated from one another entirely.

The Mark II inker has been worked with less than one milliampère of current. A current of 10 to 15 should however be provided if possible.

The resistance of the galvanometer is about 30 ohms, sufficient to indicate the passage of a current.

Should the magnetism become weak, the magnet may be re-magnetized as described further on.

The inker may be used as a relay, or to ring a bell by attaching wires to screws b *b*, *Plates 1 and 2*. The connections are given in *Plates 7, 9, and 10*.

Adjustments.

The proper method of adjusting an inker is as follows:—

1. Adjust screw u , *Plate 2*, until the inking disc touches the paper lightly and firmly, producing clear marks when the lever touches the screw u fairly.

2. The screw t must be next adjusted, so that the lever z may have a space to play in equal to about two thicknesses of note paper.

The screw k must be next turned until, with the armature lever z held down, a streak of light only is visible between it and the poles of the electro-magnets.

Lastly, adjust the spring w by means of the screw n until its tension is only just sufficient to raise the lever z against the stop t , when a current ceases to flow through the instrument.

Adjustments
of inkers,
Marks I and
II.

The inker is now in its most sensitive condition ; for strong currents, the electro-magnet should be lowered by turning screw *k*, and if necessary, spring *w* should be tightened ; but *t* and *u*, when once fairly adjusted, should not again be touched.

The speed of the clockwork, which should be about 6 feet per minute, may be regulated by removing the top and end slides of the case, as explained before, and adjusting the little screw which regulates the distance to which the fan of the butterfly regulator flies out. To increase the speed, decrease the extent to which the fan extends when flying round ; and to decrease it, the opposite.

The worm of the axle must be kept oiled, carefully and judiciously, otherwise it will become clogged and stop the clockwork.

To short
circuit.

To test the instrument, short circuit it by joining terminals L and E, *Plate 1*. The galvanometer needle should then move freely when working by continuous current, and when the key is depressed, if working by intermittent current.

To test coils.

To test the coils, touch L with the lead from C, when the armature should be attracted.

If the galvanometer moves as above, when L and E are not connected, and yet no current flows to line, there is probably a short circuit in the lightning protector.

Lightning
protector.

The lightning protector in Mark II instrument (L.P. in all *Plates*) is of the comb description. The greatest care must be taken that the space between its points is kept perfectly clear of dust and anything which might cause a short circuit. The lightning protector in Mark II instrument is connected so as to protect both up and down lines when screw *l*, *Plate 1*, is to earth. The greatest care should be taken that this earth connection is never omitted ; for simplicity sake, the lightning protector is left out in many of the *Plates*, but it must be borne in mind, that a lightning protector attached to earth for every instrument is a necessity.

Rough
lightning
protector.

An excellent rough lightning protector may be made by screwing three little pieces of tin upon a board, arranged like the lightning protector in *Plate 1* ; their edges need not be serrated, but should be so close as to be separated by the thickness of a piece of paper only, the line and earth wires being soldered to them, as shown. These will effectually protect the coils from being fused.

In the drawer of the inker will be found a complete set of spare screws.

The repairs which ordinarily become necessary to an inker can be effected by any intelligent man, when a mechanic is not available, by attention to the following instructions:—

By the improved construction of the Mark II instrument the round bar holding the armature spring *w*, *Plate 2*, cannot be screwed too high up, as in the Mark I instrument.

To replace the armature spring, push out the keeper pin, and remove screws *m* and *n*, push the bar down-wards through tube *o* until its end is exposed, the spring can then be removed and replaced.

Should the mainspring be broken, or its ends become free, preventing it being wound up, proceed as follows: let the spring run down as far as it will, by running the clockwork till it stops. Take off ratchet wheel *y*, *Plate 1*, by withdrawing screw *e*, *Plate 1*; take out the three little screws *v v v*, *Plate 2*, push out the keeper pin and unscrew handle *h*, now the drum or barrel containing the spring can be pulled right out of the clockwork case, screw the lever handle on to the thread *H*, for convenience of handling, and take off the star wheel at the back of the drum; notice exactly the manner in which this lies, a little tongue or finger on the axle fits into one of its indentations. Notice which of them it fits into, knock out the keeper pin from finger piece on end of axle. Take out three little screws which fasten on the brass cap or cover of the drum to it, and remove the cover, now it is quite easy to take out the axle and the old spring, and we are then ready for the new one, which is issued coiled tightly up and secured by a piece of wire twisted round it, put a piece of wire or string round and round through the centre of the new spring, and tie the ends loosely so as to restrain the spring from flying into your face when it is let out, cut the wire which is round the spring and let it uncoil itself just as it will. Place the slot in one of its ends over the hook in the inside of the barrel, and then holding the drum in the left hand wind the spring into it with the right.

Replace the axle through the centre of the spring, placing the hook upon it in the slot at the free end of the spring, then replace the cap, &c., as before, place the handle between your knees and turn round the drum two or three times to "set up" the spring, i.e., to put it in a state of tension, so that the slot may not come off the hook on the axle, then replace the star wheel exactly in the position it occupied before it was removed—take care not to drive in its central screw so hard as to restrain its free action, and replace the drum in the clockwork as before.

Repairs to an inker.

To replace spring of armature.

To replace mainspring.

To remove
the coils.

To remove the coils :—

Remove the ink-well and let the spring run down, take out the paper drawer, turn over the instrument and take off the wooden base so as to expose the connections underneath, you will see a thin wooden slab covering the lower end of the coils, unscrew it very carefully and cast loose the ends of the coil wires. Then turn the instrument over, right side up, and withdraw screws *a a a*, *Plate 1*, and take the instrument off its wooden base, again turn the instrument bottom up, and withdraw the four screws holding the coils to the base and lift out the former, the little screws in the edges of the ebonite cases can then be removed and the cases drawn off.

Replace the parts in the inverse order to that described above.

Lever of
paper wheel
slack.

When wheel *g*, *Plates 1* and *2*, fails to press with sufficient strength against the paper wheel *A*, and does not draw the paper forward, take off plate *f*, by withdrawing the four little screws which secure it, and bend outwards the spring which will be found on the under side of the plate.

To re-magne-
tize the
galvanometer

Should the magnetism of the galvanometer needle become weak, draw off its brass case, first taking out the little screws near its base, then unscrew and remove the top plate *G*, *Plate 1*, on which the pointer works, and with it the magnet, which swings inside the coil, this can then be re-magnetized by rubbing its north pole with the south pole of a strong magnet, and its south pole with a north pole. The magnet of a relay or telephone can be used for the purpose, or the electro-magnet cores of the inker itself, when a current is flowing through the coils.

INSTRUMENT, TELEGRAPH, SOUNDER, UNIVERSAL PATTERN, MARK II.

Sounder.

The connections of the Sounder, universal pattern, Mark II, are precisely similar to those of the inkers, Marks I and II, except that it has no lightning protector.

The electro-magnet differs from the Mark II inker, in having only one coil of 300 ohms, instead of two coils of 150 ohms each, hence its resistance cannot be reduced by joining for quantity.

Capabilities
of both inker
and sounder.

The sounder and inker may both be worked either by intermittent or continuous current, *vide Plates 7* and *8*, or by Siemens' relay, *Plates 12* and *13*, or they may be combined with detached keys and galvanometers of Post Office patterns as *Plates 14* and *19*.

Again these instruments may themselves be used as relays as *Plates 9, 10, and 11*, in which two methods of connection are shown, one for adoption when it is convenient to use the key of the reading instrument for signalling, and one for use when it is preferable to use that of the relaying instrument; the former will probably generally be adopted.

About 30 milliampères are required to give a loud sound, but the instruments will work as relays with one.

BELLS.

The bells in *Plates 7 and 8* are shown in position to be rung by the instruments working as relays, they should never be directly connected with the line, as a slight defect would cause a total disconnection: care must be taken to insert only the right hand peg in the hole labelled "short circuit," when the circuit is being worked; if the peg be also placed in the hole labelled "dis," the battery will be also short circuited every time the armature of the inker is attracted. When the bell is to be in position for ringing the peg should be in hole "dis" only; thus both pegs should never be in at once.

If the bell fails to ring, take off the cover, and see that the spring makes good contact with the stop when the lever is not attracted. This contact should of course be broken when the lever is attracted, and the stop must be adjusted so that it will thus make and break contact successively when the current is flowing. Bells require about 12 milliampères of current.

SINGLE AND DOUBLE CURRENT.

The diagrams to *Plate 18* show circuits working by *single current*. In that system signals are formed by alternately opening and closing the circuit with the key, and thus sending to line a succession of currents all in the same direction; these are termed "marking currents."

In the *double current* system, after each marking current a reversal, or current in the opposite direction, is sent; these are called "spacing currents."

The reversals have the effect of destroying any residual magnetism in the coils of the relays, and of cancelling induction in the line, thus a much finer adjustment can be used than with single current, and much greater speed attained. Special double current keys are used in the P.O., but *Plates 19 and 20* show how the system may be worked with F.S. single current keys, provided that double battery power is available.

When D.C. circuits are temporarily out of use the wire to the centre of the battery should be disconnected, so that the cells may not be on short circuit for an unnecessary length of time.

DUPLEX WORKING.

Plate 16 shows the method of working direct current duplex with the Mark II inker, when rheostats or resistance coils are available. The resistance in these must be adjusted as described later on, it will be evident then that the current of either instrument on reaching terminal L has two paths before it, one through one coil entering at D, *Plates 2 and 16*, and leaving at U, thence through the rheostat to earth, and the other path through the other coil entering it at $\textcircled{U}$ (thus flowing through it in the reverse direction to the current through the first mentioned coil) and passing through $\textcircled{D}$ to the line wire; if these two paths are nearly equal in resistance, the current will divide itself between them, and will produce little effect upon the armature of the electro-magnet as the current through one coil will counteract the effect of that flowing in the reverse direction through the other. If now the distant operator puts down his key, he too sends a current into the wire, the effect of which is to disturb the equality of the currents in the coils, hence the current from the battery of the first-mentioned inker no longer splits nearly equally between its two coils, and consequently a signal is recorded.

The battery power at each station is generally equalized, and the clerk at one station should then adjust as follows :—

INSTRUCTIONS FOR ADJUSTING THE RECORDER AND RELAY FOR DUPLEX WORKING.

Duplex circuit
with Re-
corders as
Plate 16.

1. To adjust Rheostat :—

Station A to send signals (A B C) to station B, B meanwhile to work his key slowly, and to adjust the resistance coils, until signals from A are good, when the key is either depressed or raised.

2. To adjust Morse Armature :—

Station A to cease signalling. B to work his own key, and to adjust armature spring, until the armature is unaffected by the signals.

3. B is now ready for duplex working.

4. A is now to follow the same course.

5. B should work his key once more, to see that his instrument remains unaffected.

After one or two trials, however, the clerks will know the resistances required to work duplex, and be able to adjust with little delay or trouble.

When relays and differential galvanometers are available they should be used for duplex working, as shown on *Plates 18 or 20*, in preference to the arrangement shown for direct writing duplex on *Plate 16*. Duplex circuit with relays

The balance will be much more easily obtained and maintained by the double current system when the distance exceeds 25 miles than by any other. SC or DC.

Adjust as follows for either single or double current duplex :—

(1.) Let station A (the distant one) hold down his key, while station B adjusts his rheostat until the working of B's own key produces no effect on B's galvanometer. Adjustments

(2.) Let B hold down his key while A similarly gets his balance.

(3.) Let A send ----- while B adjusts his relay until he gets clear signals.

(4.) Let B send ----- and A adjust his relay.

The switches are provided to cut out the rheostats when it is desired to work simplex, i.e., in the ordinary way and not duplex. Use of switches.

Condensers are often used on well-insulated circuits of 100 miles in length to facilitate adjustment by balancing the static charge of the line wire; about $1\frac{1}{2}$ microfarads for every 100 ohms of line resistance is about the average required, the most suitable amount must be found by trial, remembering that to bring the condenser plates into use the ebonite pegs must be inserted, when withdrawn they are not in action. Resistance cords are used to retard the discharge of the condenser, as at P, *Plates 18 and 20*, when the length of circuit reaches 150 miles.

Plates 12, 13, and 14, &c. The relay adopted into the service is that known as the "improved Siemens' pattern," it has two coils; D and U are the ends of one, and $\textcircled{D}$ and $\textcircled{U}$ of the other coil; they can be joined in series or quantity by means of the links. When both links are between $\textcircled{D}$ and U the coils are joined in series, the whole resistance is then in circuit, namely, 400 ohms; to join for quantity correct D and $\textcircled{D}$ by one link, and U and $\textcircled{U}$ by the other, the current then splits between them, and the resistance is reduced to 100 ohms.

A zinc (or negative) current entering at D or $\textcircled{D}$ will move the tongue to the M side; and so of course will a copper or positive current entering at U or $\textcircled{U}$.

The coils are differentially wound, and can thus be joined up for duplex working, as shown in *Plates 18 and 20.*

*Adjustment
of relays.*

To adjust a relay the tongue is to be brought as near as possible to the centre between the pole pieces, which should be about $\frac{3}{8}$ ths of an inch apart; the contact screw is then adjusted so that there may be a space equal to about the thickness of a sheet of note paper between its platinum head and that of the tongue when the latter is hard against the back contact; and lastly the regulating screw is turned so that the tongue may just lie against the screw head on the spacing side.

Numbers are sometimes used instead of letters to distinguish the terminal screws; in the *Plates* they are therefore both numbered and lettered.

AUTOMATIC TRANSLATION.

It is sometimes necessary to transmit messages received from one line to another automatically, translation is then sometimes adopted; the system requires that the translating instrument shall be carefully watched and adjusted, otherwise time is lost. In a complete translator switches as shown on *Plate 17* are used to divide the circuits when desired, so that the translating station can speak to the stations on either line independently.

Plate 21 shows a simple method for translating between two circuits working by ordinary intermittent 1st Method. current, as *Plates 7* and *8*. In this case an inker or a sounder is always in the circuit, so that the passing signals can be read, and keys, so that the translating station may speak to the distant offices, but as no switches are used, the line cannot be divided.

Plate 22 shows a similar arrangement which would be used when separate keys are not available. 2nd Method.

To speak to either side, the tongues of the relays are used as switches. To speak to the up side, adjust the tongue of the up relay to lie hard against the M stop, and turn round the brass bar of the inker to connect Z and E. To speak to the down side adjust the tongue of the down relay as above, replacing the tongue of the other as usual, the inker is always in circuit.

Plate 22 shows the apparatus in position for translating by this method, the distant instruments being joined as *Plates 7* and *8*, i.e., both putting C to line, and working as direct writers.

Another arrangement is shown on *Plate 23*, switches to divide the circuit are here provided, and a sounder 3rd Method. or inker for each side. This is preferable to the other methods if the necessary apparatus are available, as when divided both circuits can be worked simultaneously, or one may be worked when the other is faulty. The relays are arranged in this case up and down respectively, that is, the current enters one at D and the other at U, hence it is necessary that the distant stations should also be joined up and down, that is to say, the up station must put C to line, and the down station Z to line. Relays should not be used at the distant stations. In this method no sounder or printer is in circuit to record the messages passing.

Plate 24 shows a more complicated but more perfect system, adapted for important circuits, where plenty 4th Method. of battery power is available. Here a relay working a sounder is always in circuit on each side for watching the working. Switches are used as before to divide the circuit, and detached keys, to speak to the distant stations, which must be joined correctly as "up" and "down." Relays may or may not be used at them. The disadvantages of this method are that two relays are included upon each line, thus increasing the resistance of the circuits, and that the battery being earthed in the centre double power is required; to obviate these, the arrangement shown on *Plate 25* is proposed, the switches divide the circuit when required, 5th Method. and divert the incoming currents to relays working inkers or sounders, one of which then speaks to each line. In this method it is important that the distant stations on each line should be joined as "down," i.e.,

should in all cases send zinc currents to the central or translating station. With these examples no difficulty it is thought will be found in modifying the arrangements as may be required, bearing in mind the rule that a zinc current entering at D has the same effect on a relay as a copper current entering at U, in both cases putting the tongue over against the M stop. The translators are all designed for single current circuits.

THE VIBRATING CURRENT SYSTEM.

Plate 26.—A vibrating sounder connected as a shunt to the line on depressing the key has the effect, whenever a current is sent to line from the key, of making and breaking contact with extreme rapidity, thus each current sent from the key is broken into a succession of currents, each of extremely short duration, and a musical note is sounded in the telephone, longer or shorter in duration, accordingly as a dash or dot is signalled. This system has been successfully worked through 15 miles of bare wire lying on the ground, and even when part of the line was thrown into a canal, the signals were perfectly readable.

The figure marked "Intermediate" on *Plate 26* shows the system of connections adopted in the first pattern of vibrators which were adapted from old FS sounders; the construction of these instruments was found to be insufficiently solid and difficulty of adjustment arose; the resistance of the coils were also too high.

A second pattern was designed as shown in the figure marked "Up." In this the current through the coil is maintained by means of a switch, and is not broken by the key as in the first pattern; the adjustment is therefore maintained better; only six of these have been purchased.

The figure marked "Down" shows a revised pattern, which however has not at date of going to press been sealed.

The switch in this pattern is dispensed with, and a small additional key* is added, which, when closed, has the effect of short circuiting the telephone, and of increasing the effect at the distant stations.

* The connection through the instrument for received currents is effected by a short circuit from the back contact of the key to the base and terminal U, this cuts out the resistance of the magnet coil.

TELEPHONES.

GOWER BELL TELEPHONES.

Gower Bell telephones have been largely introduced into the service; and, as the method by which speech is transmitted by them is frequently not understood, a few words in explanation of the diagrams may not be out of place.

Plate 27 shows the arrangement of the form of instrument which has been adopted.

Plate 28 shows the paths traversed by the various currents.

When the tubes* are lifted out of the holders, the levers rise and short circuit the battery through the inner coil of the induction coil and the microphone. When now a person speaks against the board under which the microphone is fixed, the resistance which the latter opposes to the passage of the current is varied in correspondence with the vibrations of the board, caused by the sounds striking against it. These variations in the resistance cause again corresponding variations in the battery current, which, as above explained, is flowing through the primary coil of the induction coil. (See *Fig. 2, Plate 28*).

Anyone who knows the principle of an induction coil will understand that each variation in the current through its primary or inner coil causes a current to flow through its secondary or outer coil; the path of this secondary current is shown on *Fig. 1*; it passes to line to the distant telephone, and flows through it along the same path (as shown on *Fig. 1*), passing in its course through the little coils wound on the poles of the large magnet; in doing so it temporarily strengthens or weakens their polarity, and thus the tin plate opposite to them is attracted with more or less strength, and caused to vibrate, thus setting the air in motion, and producing sounds in the ear tubes corresponding to those which struck against the board of the transmitter at the other station; the continuity of the wires can be tested by the help of *Plate 28*.

To test the primary circuit, having first removed the tubes, take the C of the battery off terminal C of telephone, and put it on a detector joining the other side of detector, first to terminal C and then to ter-

* The listening tubes which are screwed on directly beneath the tin disc, are omitted in the plates for sake of clearness.

minal L; if you get a deflection in the former case it proves that the circuit through the primary coil is not disconnected; if in the latter, it proves that through the secondary coil (*vide Figs. 1 and 2, Plate 28*).

But a telephone is of little use unless an arrangement for attracting attention is provided, and therefore a chattering bell is added to the apparatus; and it is this part of it which causes almost all the difficulties which are experienced in working on this system. Only two or three cells are required for speaking any distance, but many more according to the length of the circuit are wanted to ring.

Fig. 3 shows the course of the outgoing ringing current, the circuit being completed by pressing the push-piece at the top of the instrument. The ear tubes when ringing must be in position so as to depress the levers.

Fig. 4 shows the course of the ringing current arriving from a distant station; it passes through the lever and through the bell coils; thus the lever is attracted and breaks contact and then immediately flies back and again makes contact, and so on, producing a series of blows on the bell.

To test the outgoing ringing current, put a detector between terminals L and E, leave the ear tubes in their sockets and depress the knob and you should get a deflection, *vide Fig. 3*.

To prove that the circuit for the incoming ringing current is complete and the bell in order as before, leave the tubes in their places and all wires on, and join terminals B and L with a short wire, when the bell should ring at once.

But the rapid breaking of the contact by the bell nearly incapacitates the current from performing any other work,* and hence if three or more stations are on the wire, little or no effect is produced on the bells of the more distant instruments. Some telephones have therefore been supplied with a little coil of wire of the same resistance as the bell coils and called a shunt; this is inserted in the line circuit beside the bell coils so that the current splits, half of it only goes through the bell coils and the other half flows on to the next station through the shunt, and thus the circuit is not wholly disconnected, but this device is not wholly satisfactory.

Plate 29 shows the best arrangement for obviating the difficulty; a detached bell is there supplied, and instead of bell coils and lever inside the telephone, a little relay is substituted which makes contact and

* This is due to a want of unison in the periods of vibration of the armatures, one breaking contact as another makes contact, and so on.

closes the local circuit through the bell as shown in dotted lines in *Plate 29*, without, as in the last case, constantly breaking connection, thus any number of telephones may be joined up together.

Care must be taken with telephones of all sorts, as explained before in the remarks on bells—that the spring of the bell lever makes good contact with the stop, when the lever itself is not attracted, and breaks contact when it is attracted; and also that the battery is not kept on short circuit by leaving the tubes out of their holders, also that the knob at the top of the instrument makes good contact with its two contact points.

The resistance of the magnet	coils is	..	..	..	..	200 ohms.
"	"	primary	"	..	..	1 "
"	"	secondary	"	..	..	100 "
"	"	bell	"	..	..	100 "
"	"	microphone	"	..	..	8 to 10 "
"	"	shunt	"	..	..	100 "
"	"	shunt and bell	"	..	..	50 "
"	"	relay	"	..	..	100 "
Current required for an ordinary telephone		..	..	..	..	20 milliamperes.
"	"	a shunted	"	..	..	40 "
"	"	a telephone with relay	..	..	..	16 "

ADER'S TELEPHONES.

Patterns of Ader's transmitters and receivers having been lately sealed, a diagram showing their arrangement is given at *Plate 31*. The principles of construction are the same as those of the Gower Bell telephone, although the details are otherwise arranged. The shape of the microphone is different; it has 20 points of contact instead of only 16, as in the Gower Bell. The magnet of the receiver is circular for convenience of holding it and for hanging it upon the switch hook. When thus placed, the current through

the primary coil is cut between springs A and B, and the instrument is in position to send or receive a ringing current.

Two or three cells only should be joined to terminals marked P T (*pour télégrapher*) for the speaking battery. If this number is insufficient to ring the bell through a long circuit, a separate ringing battery must be connected to terminals PS (*pour sonner, to ring*).

INTERCOMMUNICATION SYSTEM OR TELEPHONE EXCHANGES.

These have been arranged in several fortresses, dockyards, &c.

Many systems are followed in civil practice, but that shown on *Plate 30* has been found most adapted for military requirements.

The switch boards are made with any number of holes up to 100; through each hole protrudes a pair of brass fangs, like the jaws of a pair of pincers; so long as these hold together by their spring, the line wire attached underneath to the upper jaw is in electrical connection with the earth attached to the lower jaw, and thus any current sent from the distant station actuates the indicator. If now the jaws are forced apart by the insertion of the peg, the line is cut off from the earth, and may be connected by the wire between the pegs with any other line or with the central telephone, by inserting the other peg into the corresponding hole, thus any two stations may be put into communication with one another, or any station may be spoken to from the central station.

Every distant station can call up the Central Station, as, whenever any person at a distant station—say at No. 3—depresses the bell-push at the top of his instrument, a current passes through No. 3 indicator at the Central Station; this is so constructed that the passage of the current deflects the needle or drops a little shutter, which in falling closes a local circuit and rings a bell.

The attendant, watching at the central office, replies by connecting the central telephone with the line on which the call was received by inserting the switch pegs, and, by depressing his bell-push he rings the bell at No. 3 station; both clerks then proceed to speak in the usual way; if necessary No. 3 might be

then connected with any other line and station whom he may then ring up and speak to as usual; he must, however, take care to ring at the conclusion of the conversation, his current will then deflect the needles or drop the shutters at the Central Station and advise the attendant that the conversation being over the lines may be restored to their normal condition by removing the pegs from the holes in the switch board.

In the diagram only one instrument is shown upon each line, for simplicity; but two intermediate stations may be introduced in addition, upon any line, but then all the telephones must be those with relays and separate bells, as *Plate 29*.

If it is found that the current from one line not only deflects the needle on the indicator belonging to that line, but also the needles of other circuits, the resistance of those circuits must be increased or the earth improved, or both.

Each switch peg is fitted with a brass projection, or nose, which ensures that it must always be inserted into the holes in such a position that the same side will always be in electrical contact with the upper jaws of the switch holes.

ABC APPARATUS.

As Wheatstone's ABC apparatus are used on circuits at some military stations, diagrams of their connections are given on *Plates 32 and 33*. Most of the adjustments of these apparatus are of too complicated and delicate a description to be undertaken by any but skilled mechanics.

The only skill required in working the ABC instrument is that necessary to turn the handle with a proper and uniform velocity, and not excessively fast, with the right hand, while depressing one key at a time with the left. When not in use one key should be left depressed, and the handle turned downwards, otherwise in instruments of old pattern a disconnection is often caused. The bell must be kept wound up, and care taken not to overwind it by violent jerking of the handle. More than five (at the most) of these instruments can seldom be successfully worked on one circuit, and if possible the number should not exceed four.

PARTICULARS OF BATTERIES.

IN USE IN THE POST OFFICE.

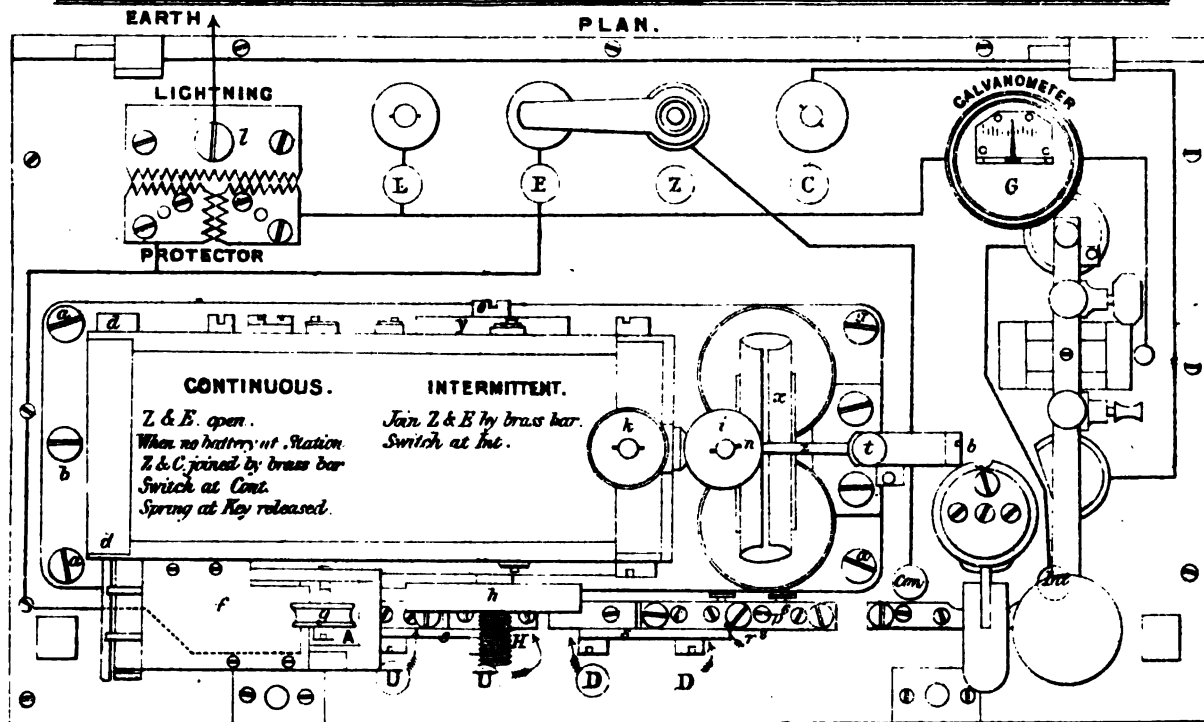
IN USE IN THE WAR DEPARTMENT.

Description of Battery.	Electro- motive force.	Resistance.	Description of Battery.	Electro- motive force.	Resistance.
	Standard.			Standard.	
	Volts.	Ohms.		Volts.	Ohms.
Bichromate .. large	2·14	2	Grove's firing	2·0	·08 to ·2
„ .. medium	2·14	3	Leclanché „	1·5	·15 to ·25
Daniell large	1·07	4	„ agglomerate firing	1·5	·1 to ·2
„ small	1·07	10	„ „ field service	*1·25	2 to 4
Chamber .. large	1·07	5	„ „ No. 3 ..	1·5	·6 to 1
„ .. small	1·07	7	„ No. 3, with in- creased resistance	1·5	3·25 to 3·5
Ordinary.. .. .	1·07	10	„ test cell	1·5	12 to 14
Leclanché .. old	1·6	2	Daniell signalling, low resistance.. .. .	1·0	1
„ gravity and agglomerate	1·6	1½	„ P.O. ordinary ..	1·07	10

* This is purposely put rather lower than the proper E.M.F. of a Leclanché cell to correspond with the power which should be calculated for on service.

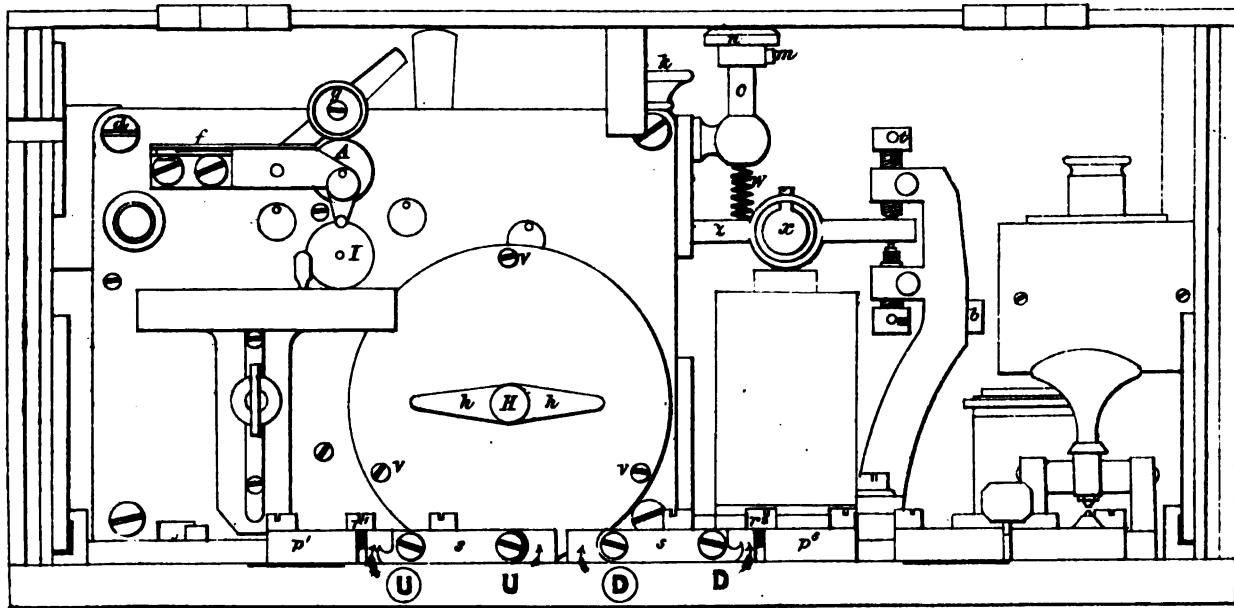
INSTRUMENT TELEGRAPH MORSE RECORDING UNIVERSAL PATTERN MARK II.

1.

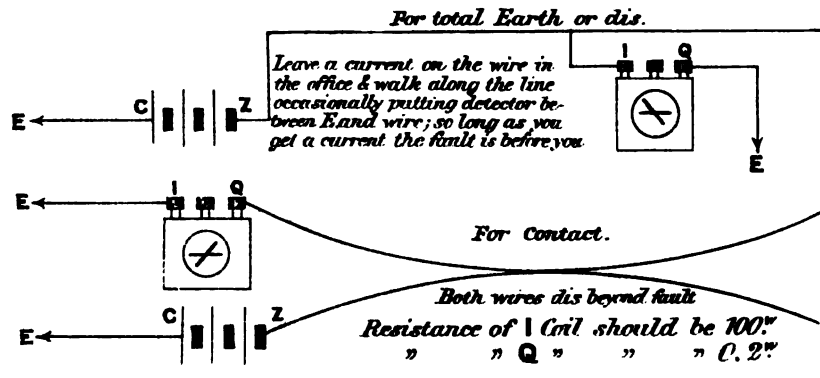
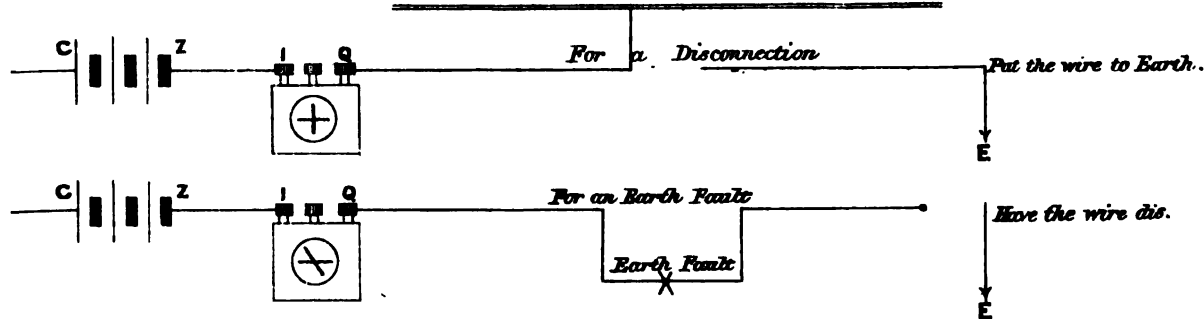


INSTRUMENT TELEGRAPH MORSE RECORDING UNIVERSAL PATTERN MARK II.

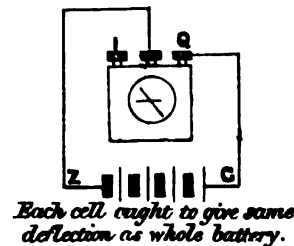
ELEVATION.

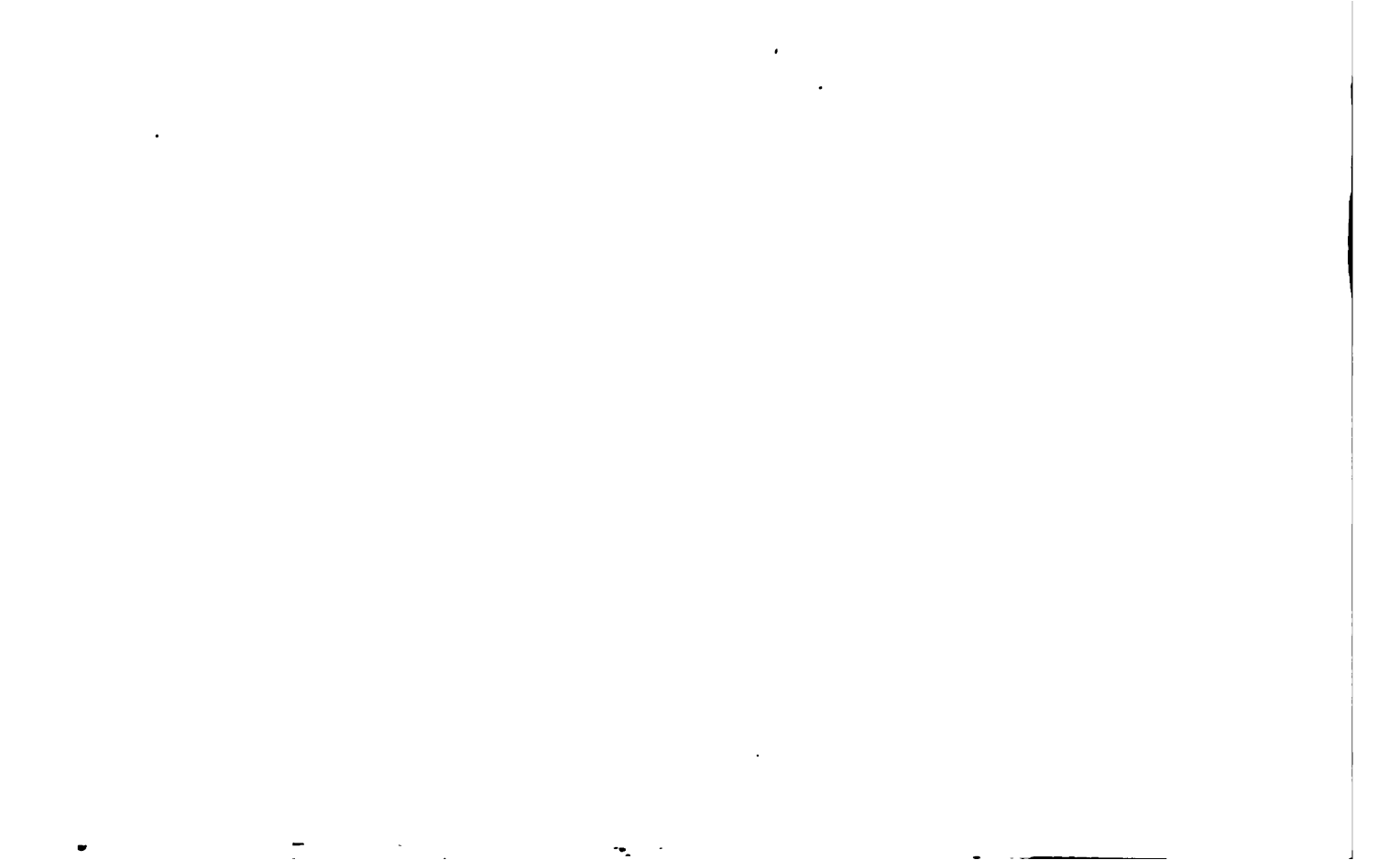


TESTING WITH DETECTOR.

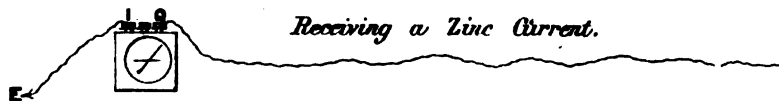


TO TEST A BATTERY

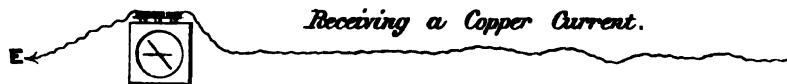




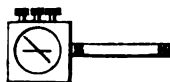
DETECTOR. CONTINUED.



Receiving a Zinc Current.



Receiving a Copper Current.

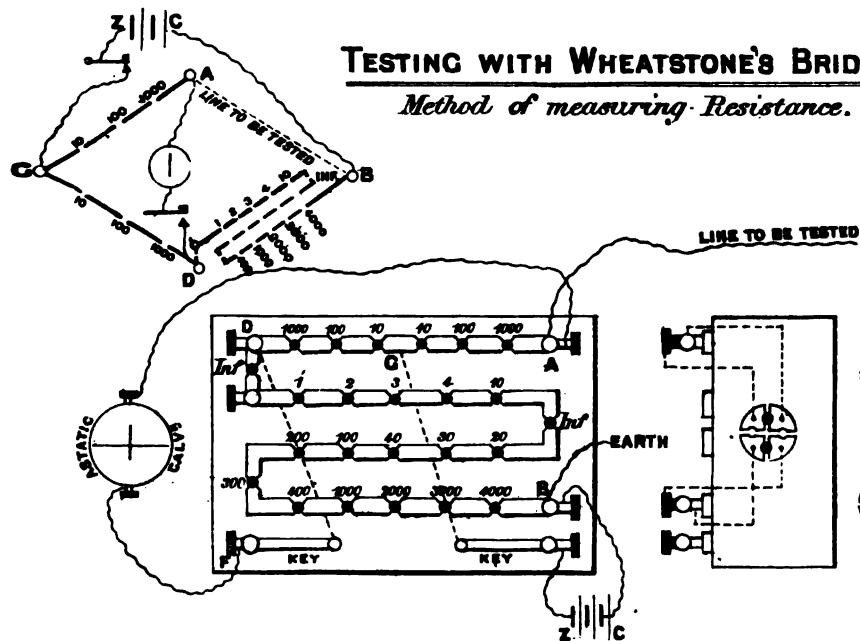


To test a magnet. Place the South pole against centre of Detector and note the deflection and compare with that caused by a known good magnet. A good magnet should sustain its own weight when hanging from a mass of Iron.



TESTING WITH WHEATSTONE'S BRIDGE.

Method of measuring Resistance.



*Resistance of Astatic Galvanometer should be 1000^Ω
Deflection should be 45° with standard cell thro' 3500^Ω
Vibrations should not be less than 10.*

To test a line for resistance of Conductor put it to earth at far end.

To test for insulation resistance it must be left dis. at far end.

To test a loop, join one end to A and the other to B and use no earth.

Resistance must always be unplugged in AGD otherwise no current will pass through the galvanometer.

If the resistance in AG is equal to that in CD the resistance in DB measures that of the line.

If that in CD is ten times or one tenth that in AG the resistance unplugged in DB will correspondingly be ten times or one tenth that of the line.

The plug switch reverses line and earth and enables tests to be taken with reverse current quickly; it is not always fitted to military instruments.

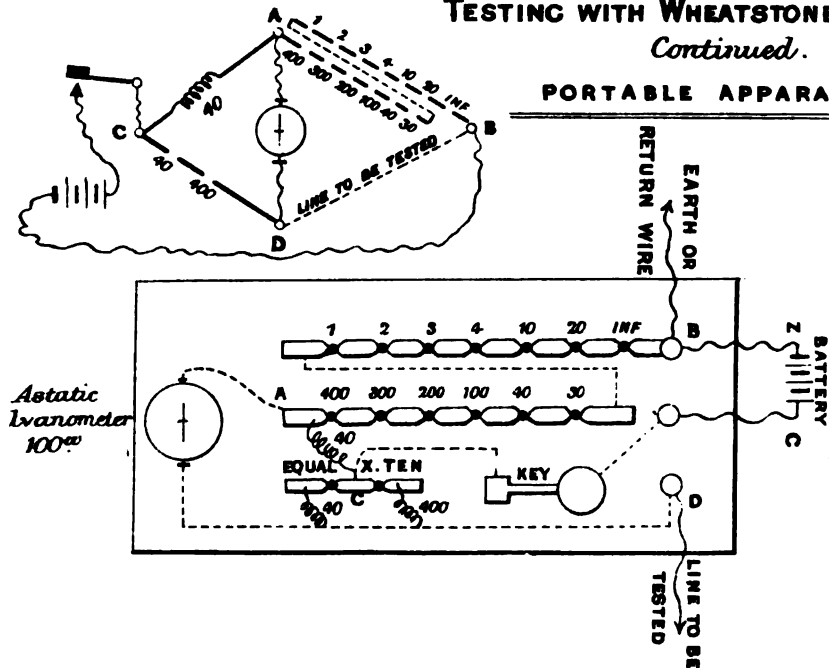
ZINC TO LINE. COPPER TO LINE.



TESTING WITH WHEATSTONE'S BRIDGE

Continued.

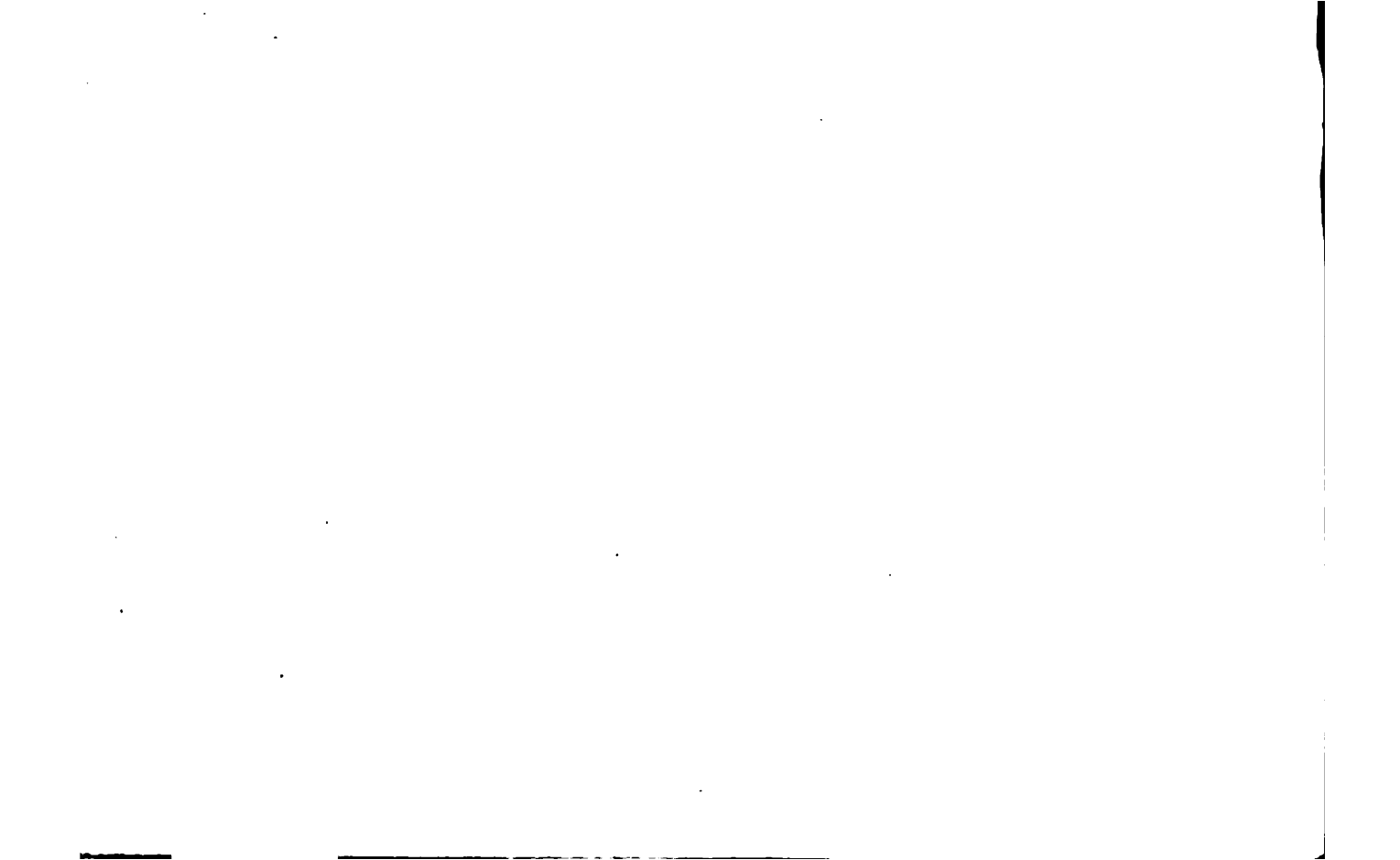
PORTABLE APPARATUS.



A peg must be inserted at either hole EQUAL or X TEN not in both; when balance is obtained with peg at EQUAL the res^{ce} unplugged in A. B. measures that of line, when with peg at X TEN, it must be multiplied by 10.

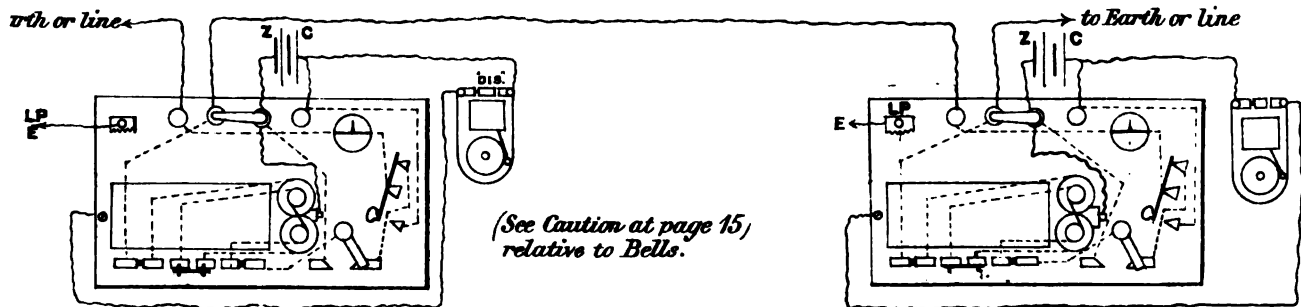
Use the magnet to reduce deflections caused by Earth Currents so as not to exceed 30°.

In testing Lightning Conductors vide App. II. Army Circulars 1st Sept. 1881.

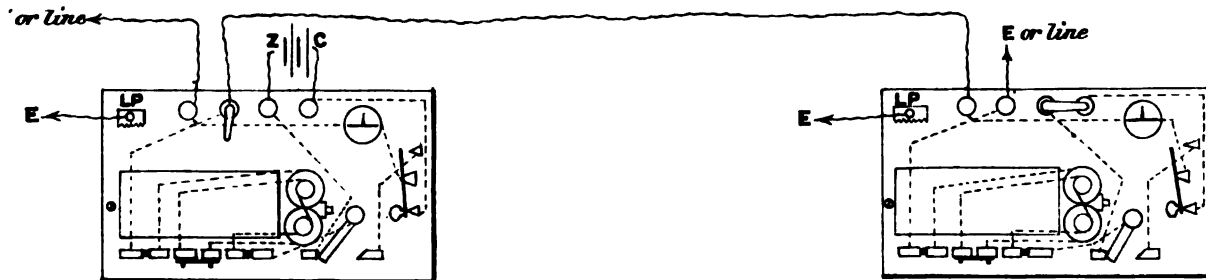


TWO INKERS MARK II WORKING BY INTERMITTENT CURRENT.

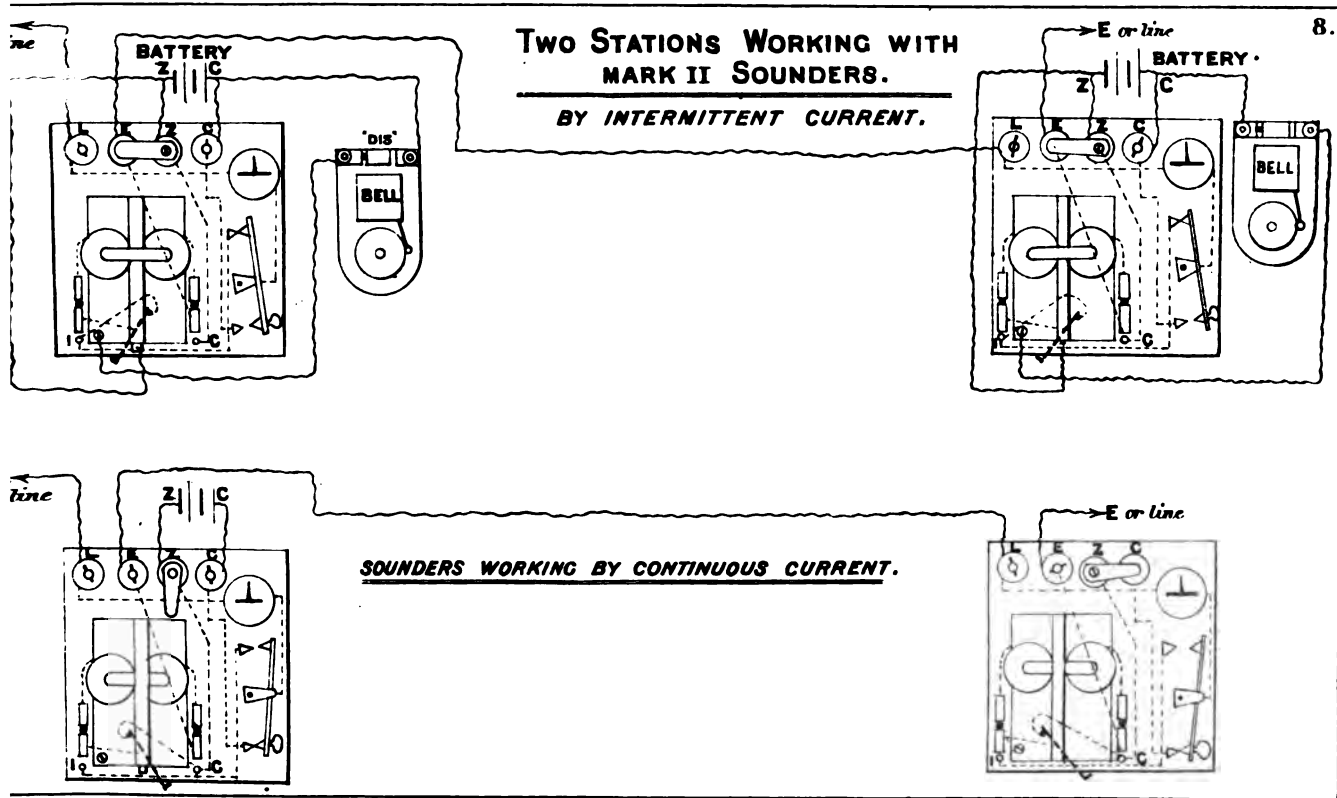
Mark 1 Old pattern Inkers are to be joined up similarly.

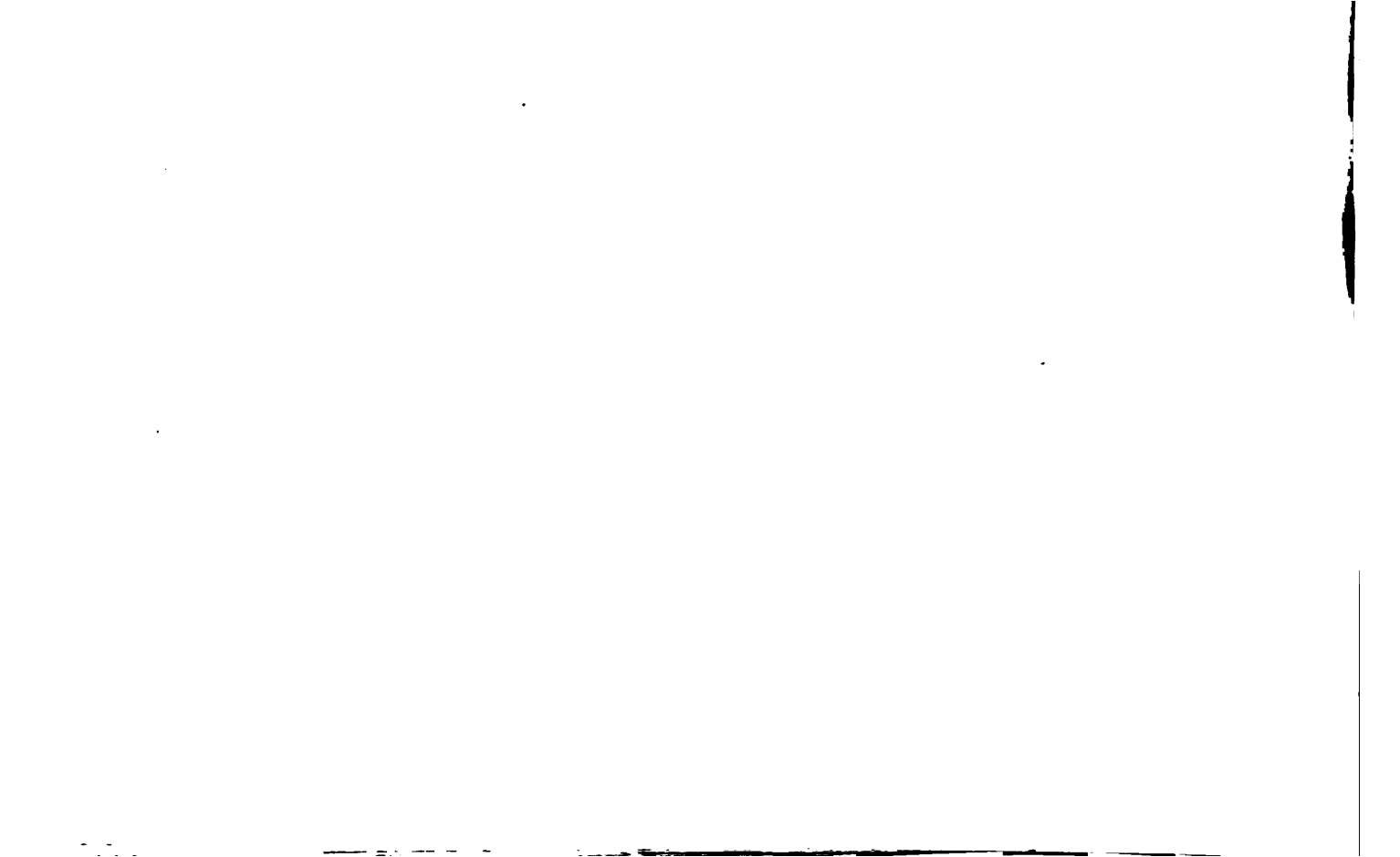


BY CONTINUOUS CURRENT.



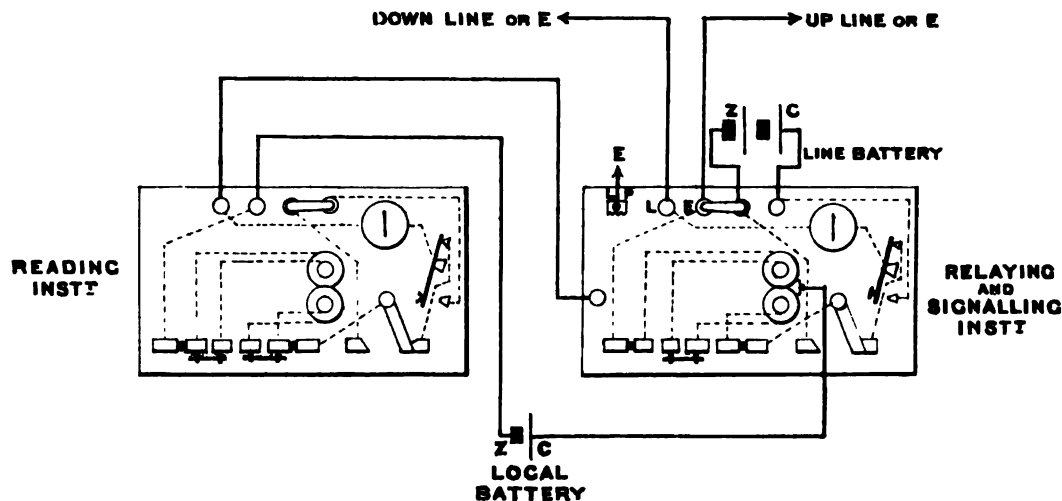






ONE INKER WORKING AS RELAY FOR ANOTHER.

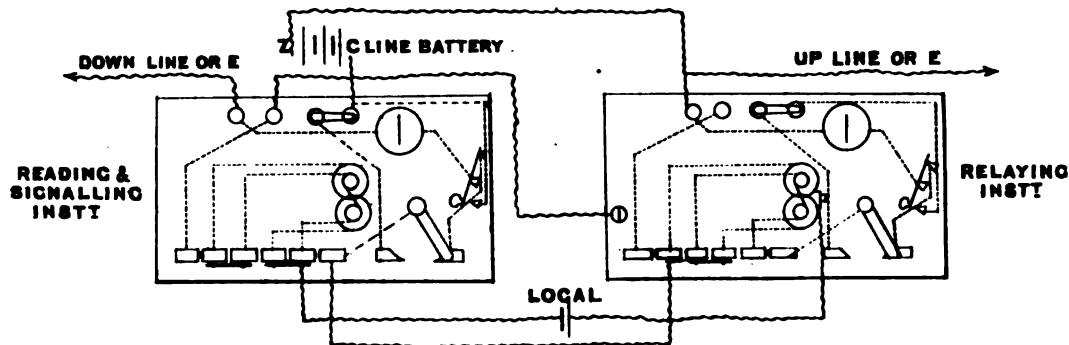
Similar connections for Up & Down Stations.



ONE INKER WORKING AS RELAY TO ANOTHER.

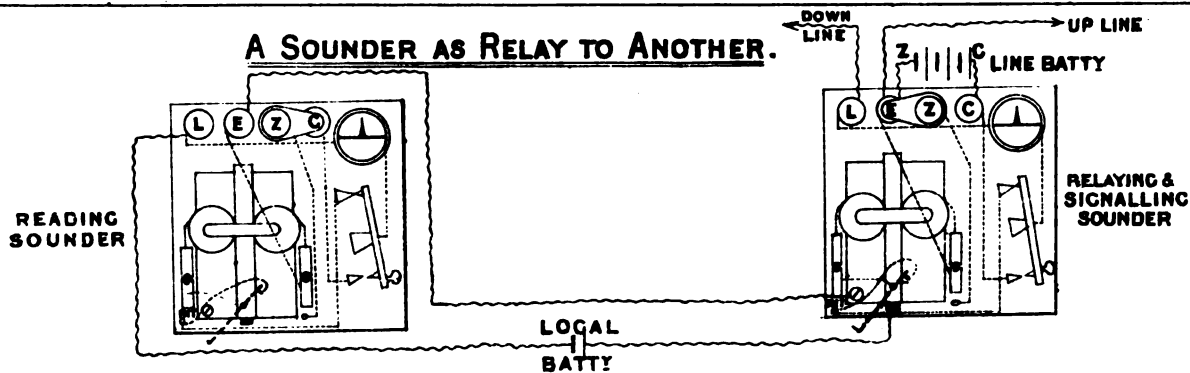
Similar Connections for Up & Down Stations.

ALTERNATIVE METHOD.

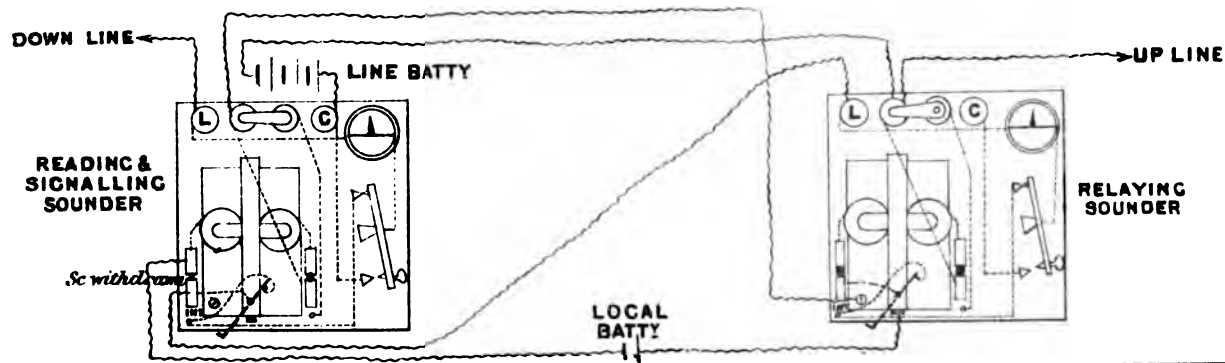




A SOUNDER AS RELAY TO ANOTHER.

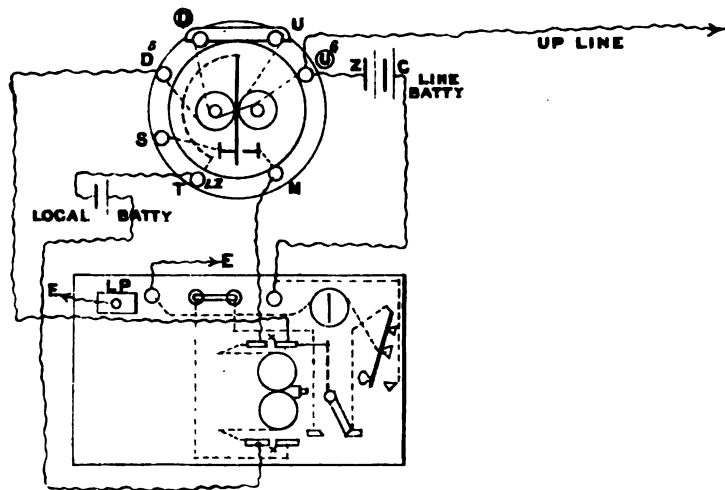


ALTERNATIVE METHOD.





AN INKER MARK I OLD PATTERN WORKED BY RELAY.
WHEN A SEPARATE KEY IS NOT AVAILABLE.



DOWN STATION.

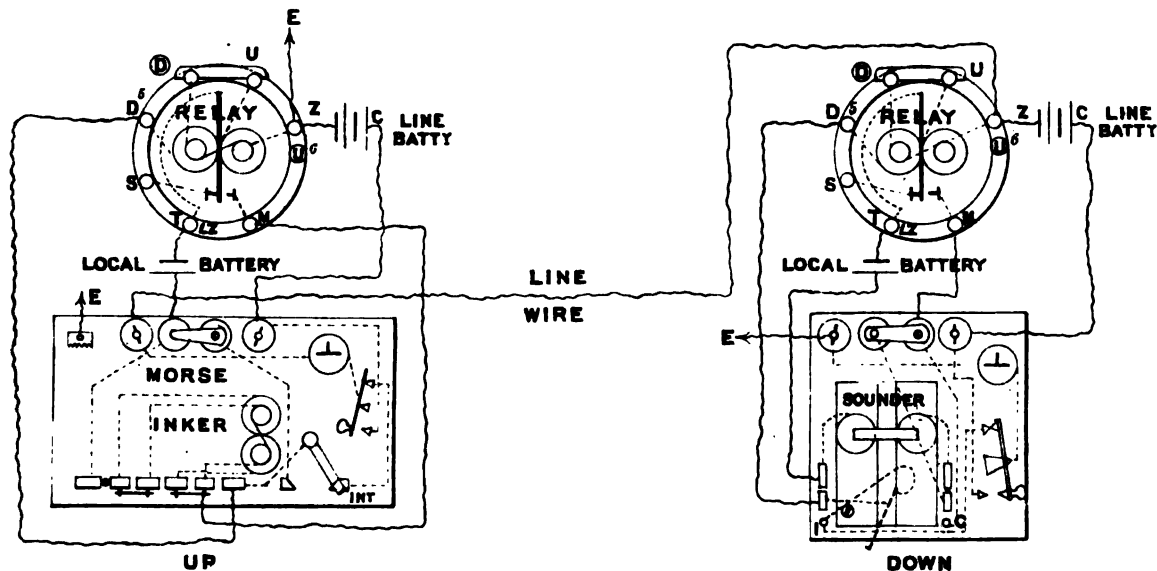
*At an Up Station the Line & Earth wires are to be reversed.
 Screws at X between Coil Blocks are to be removed as shown.*

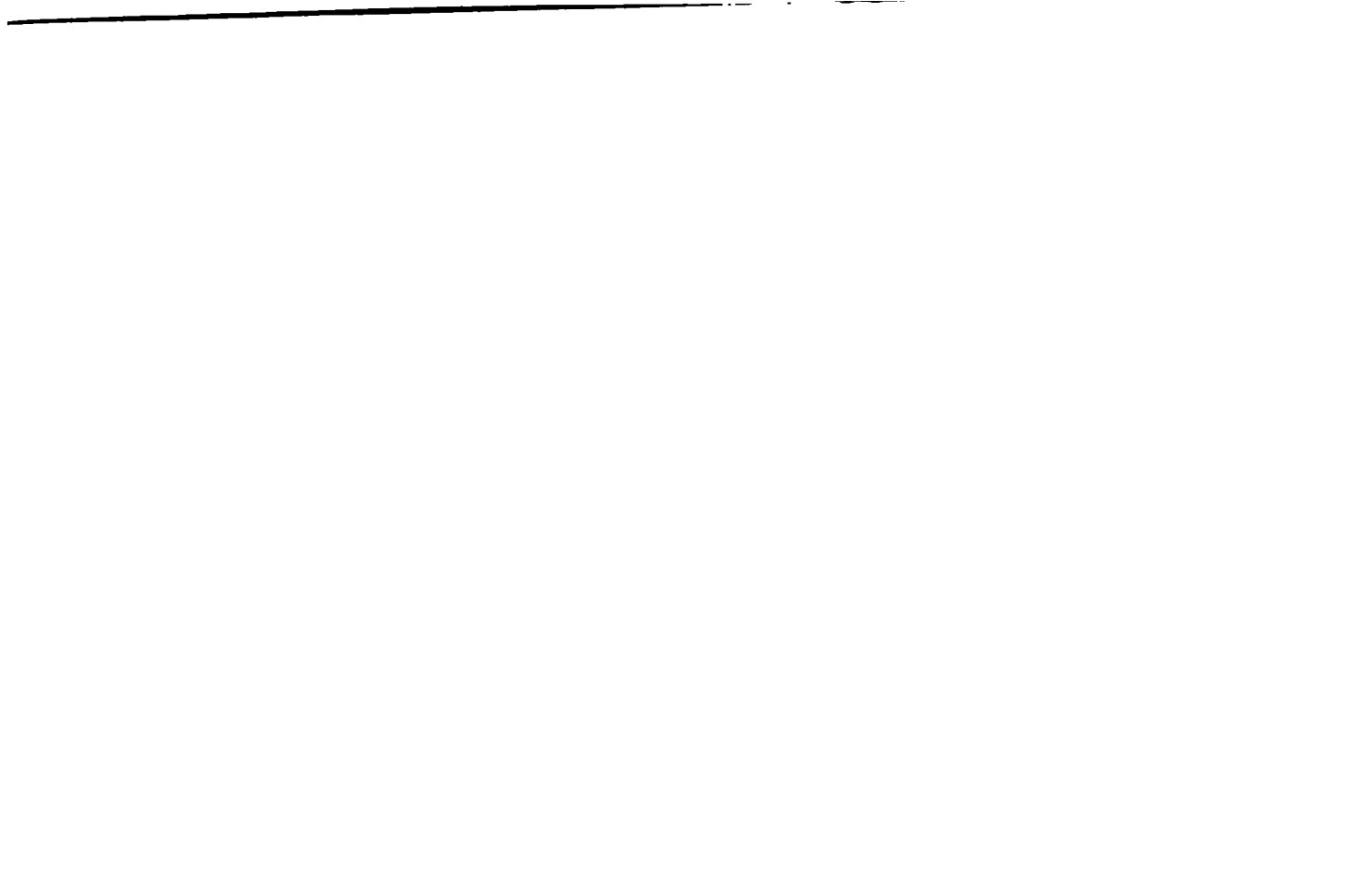


A CIRCUIT WORKING BY RELAYS AND LOCAL BATTERIES.

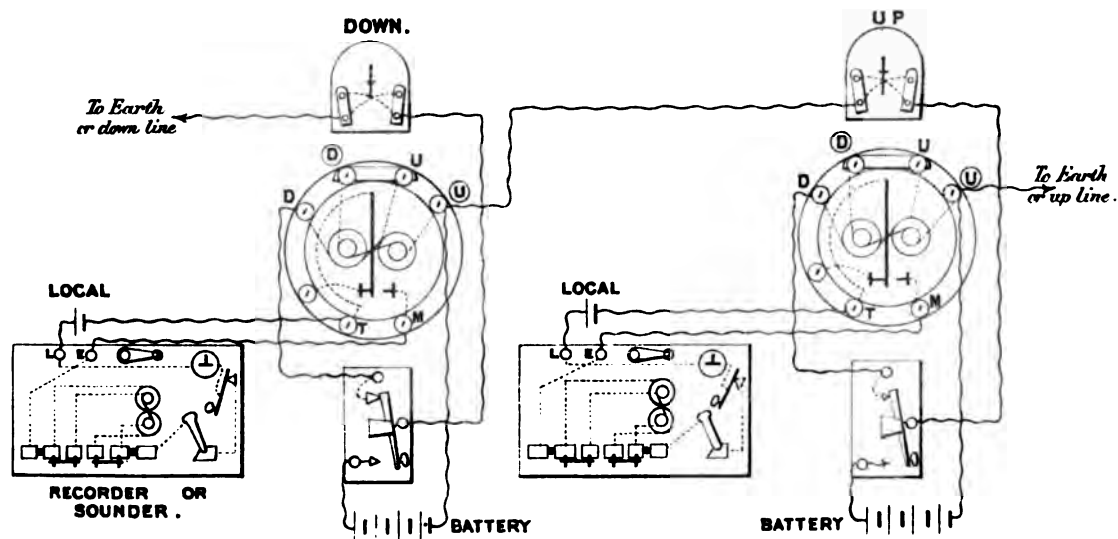
A SOUNDER AT ONE END AND INKER AT THE OTHER.

Remove screws between coil blocks as shown.





SINGLE CURRENT CIRCUIT. WITH RELAYS.



*Resistance of each Coil of Relay 200.
" " " " " " Galvanometer R.*

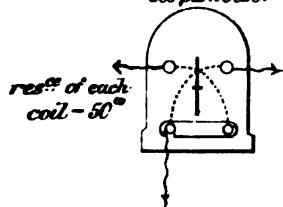
7

GALVANOMETERS.

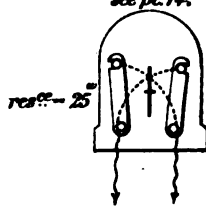
*for Single or Duplex working
or for Testing.*

MILITARY PATTERN.

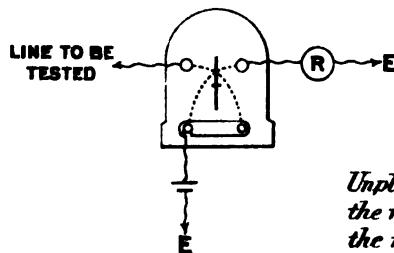
DUPLEX.
see pls. 16&18.



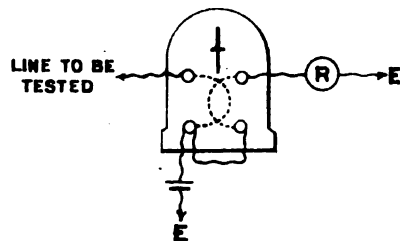
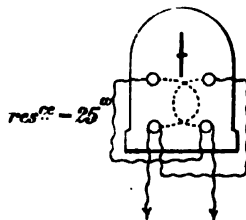
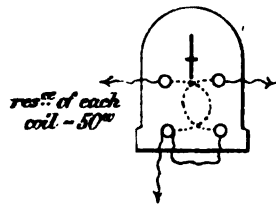
SINGLE CURRENT.
see pl. 14.



TESTING.



POST OFFICE PATTERN.



.

.

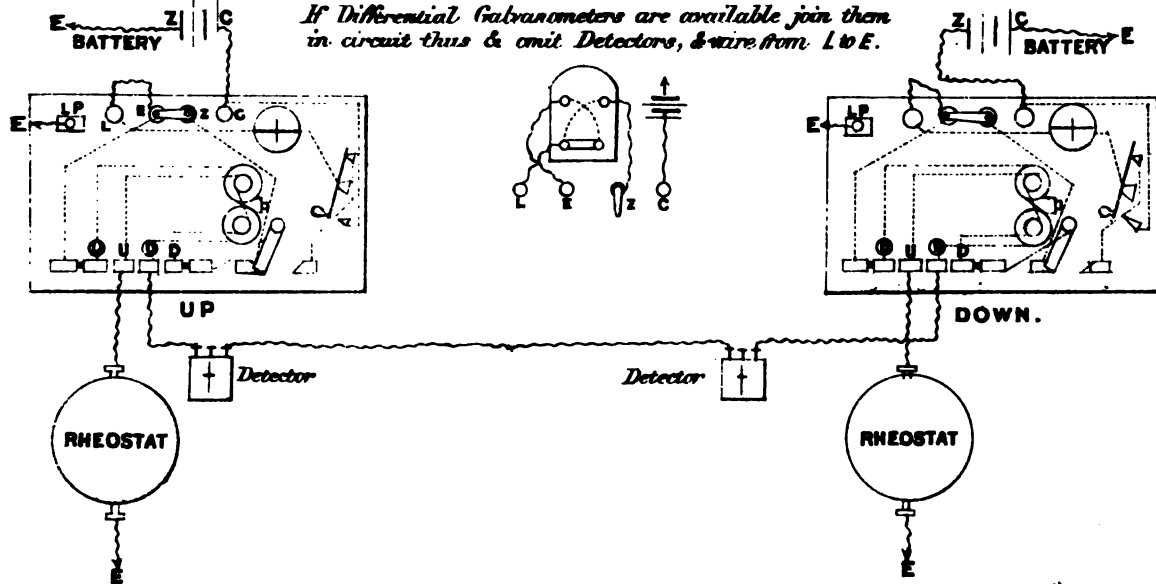
TWO STATIONS WORKING DUPLEX.

WITH MARK II INKERS AND RHEOSTATS.

The general rule is that the batteries at each end should be equal and that there should be no intermediate Stations.

The Resistance in each Rheostat must be adjusted as directed in the notes.

If Differential Galvanometers are available join them in circuit thus & omit Detectors, & wire from L to E.

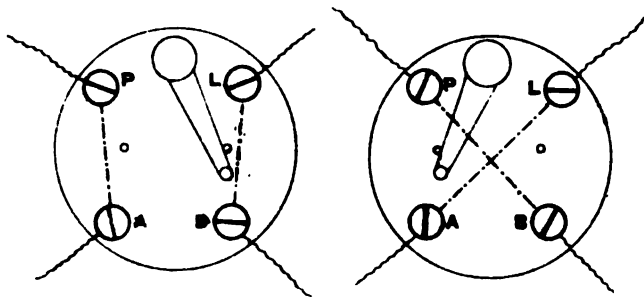




REVERSING SWITCH.

Handle to Right..... P to A, L to B.

" " " Left --- P to B, L to A.



Ans.

(continued)

10

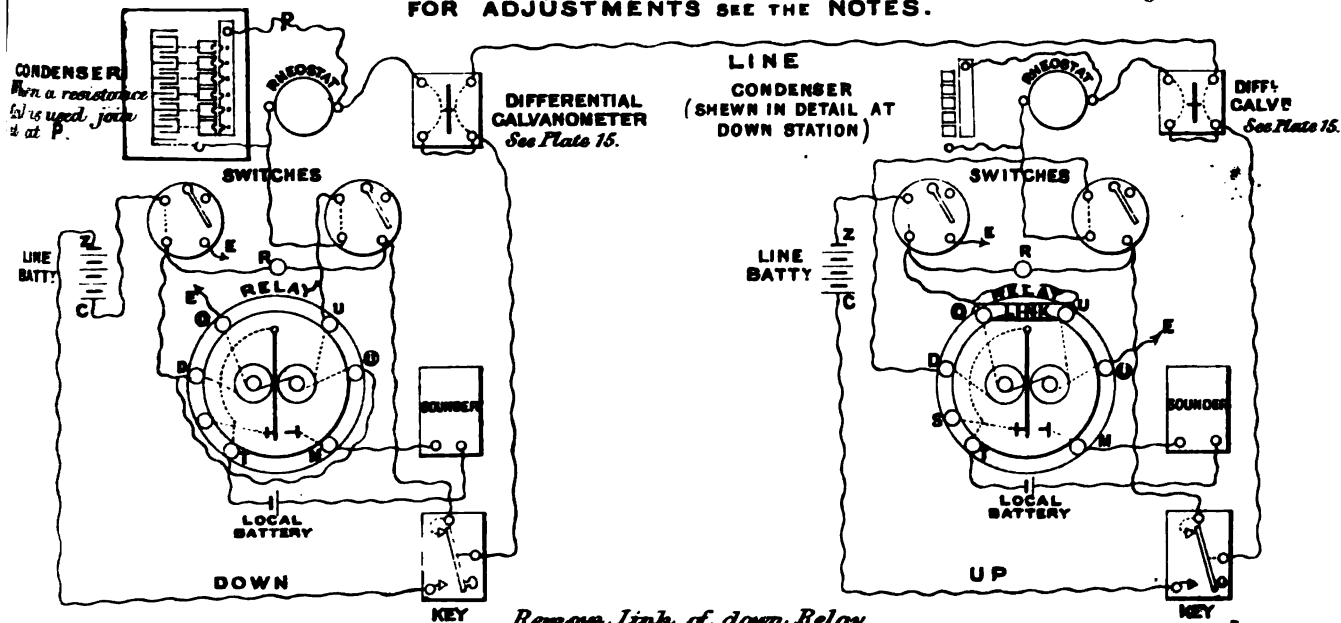
1

Down

10

DUPLEX CIRCUIT WITH RELAYS.

Put Switch Handles to the Right for Duplex, to the Left for Single working.
FOR ADJUSTMENTS SEE THE NOTES.



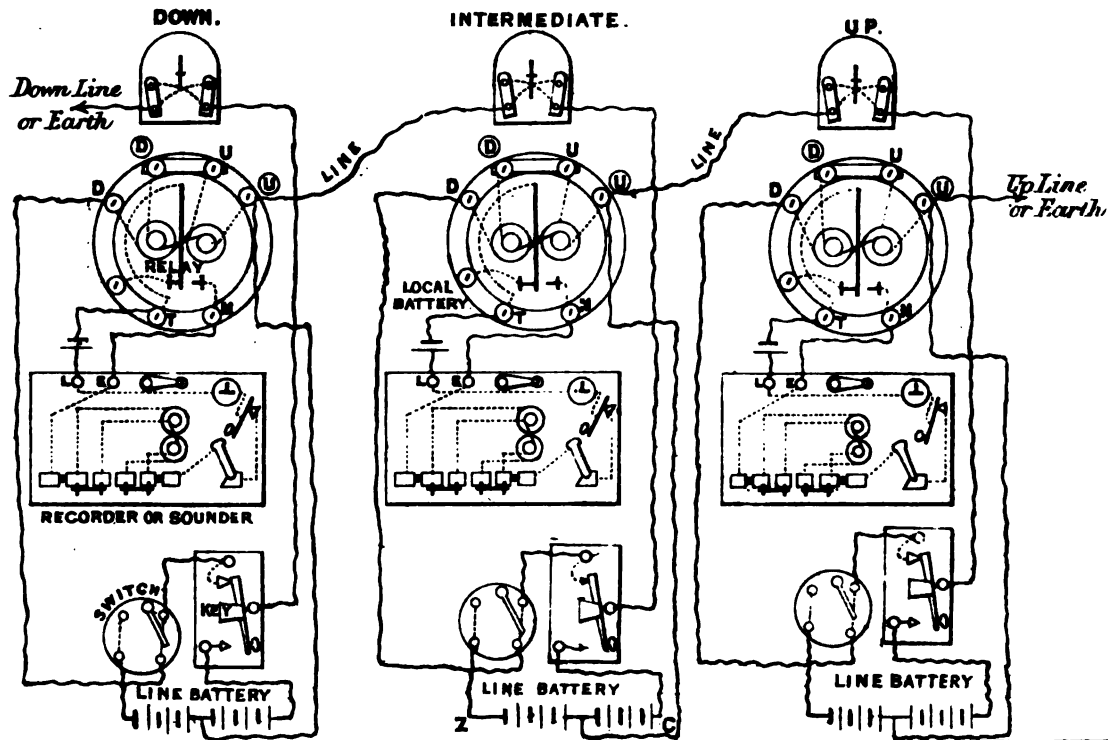
*The Switches should be joined by a wire as shown and if the Battery exceeds 10 Cells a Resistance equal to it should be inserted at R.R.
When 6 Principal duplex switches are provided they must be joined up as shown in P.O. diagram book.*

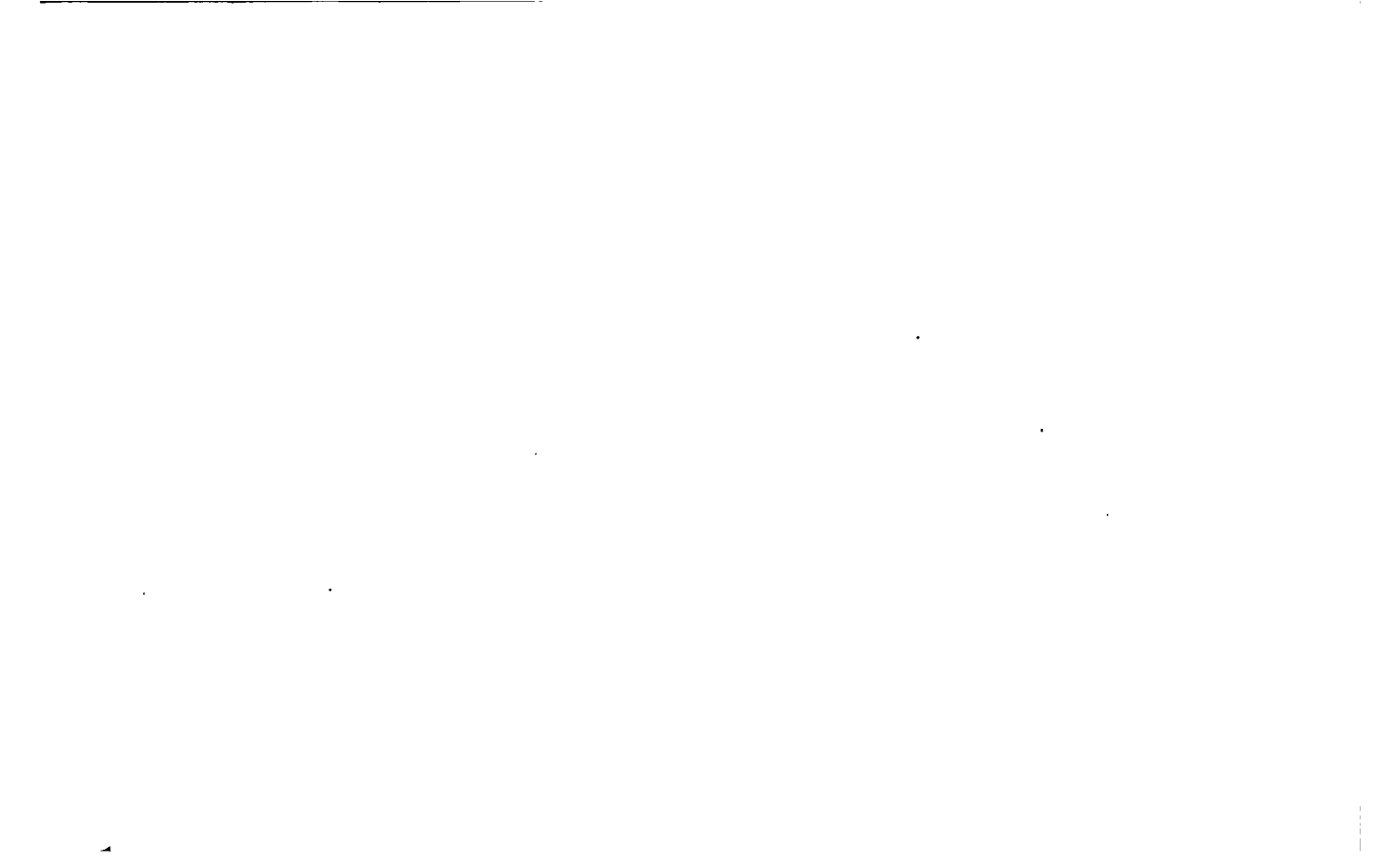


THREE OFFICES WORKING BY DOUBLE CURRENT, WITH SINGLE CURRENT KEYS.

19.

Switch handles to the Right for Receiving; to the Left for Sending.





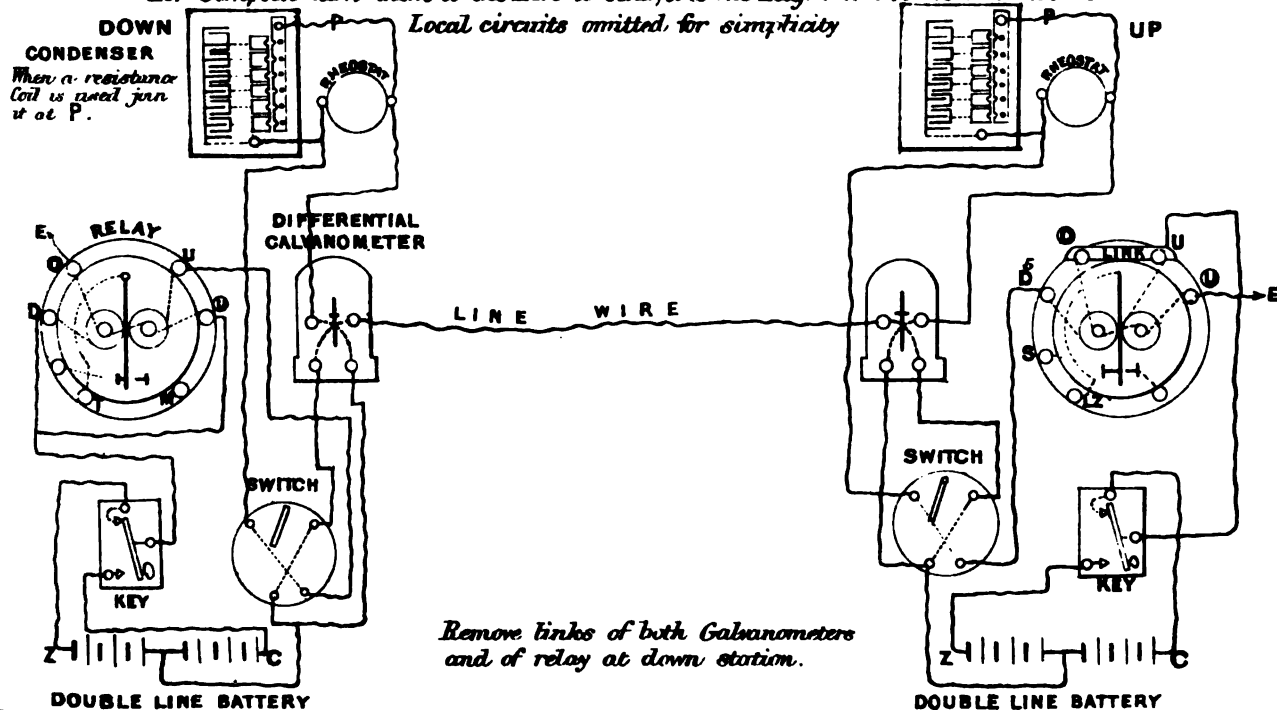
DOUBLE CURRENT DUPLEX, WITH SINGLE CURRENT KEYS.

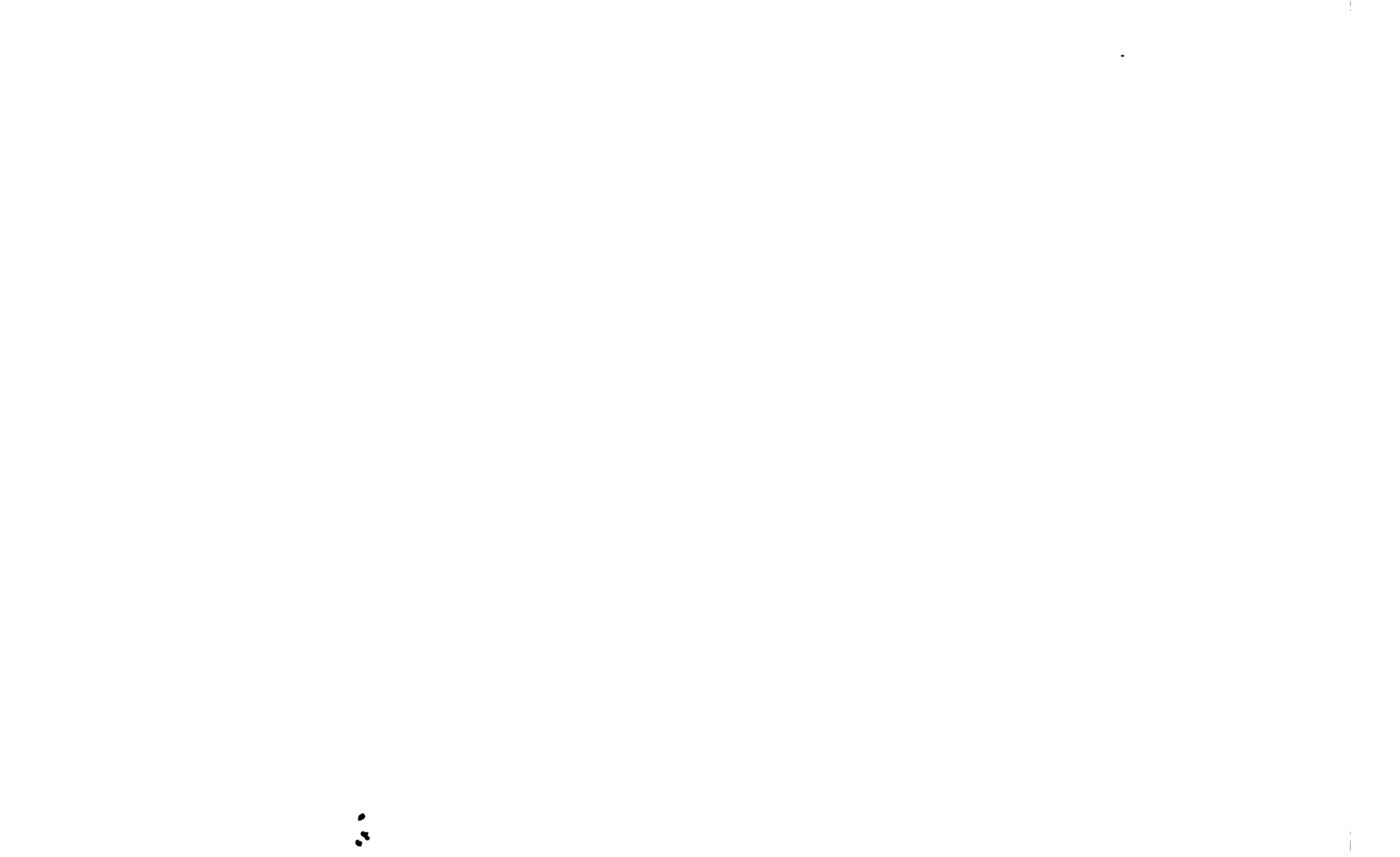
20

Turn Switch handles to the Left when working duplex.

For Simplex turn them to the Left to send, & to the Right to receive as in Pl. 19.

Local circuits omitted for simplicity

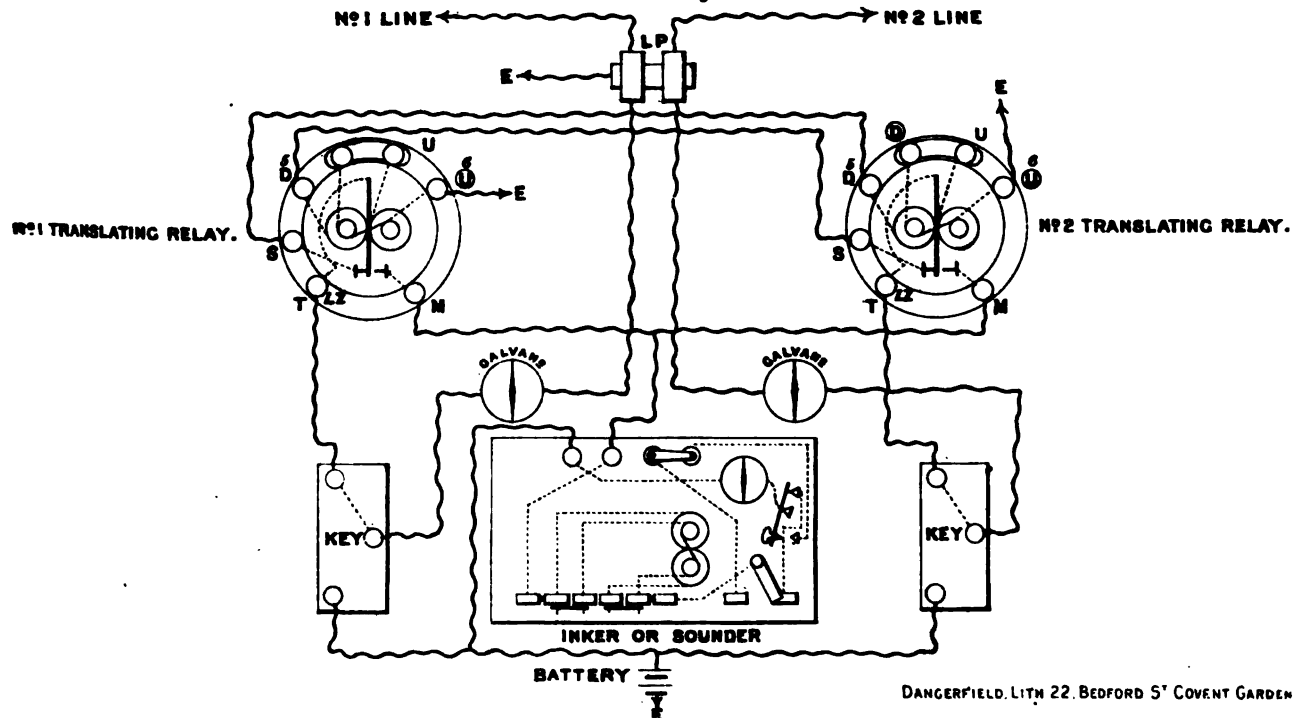


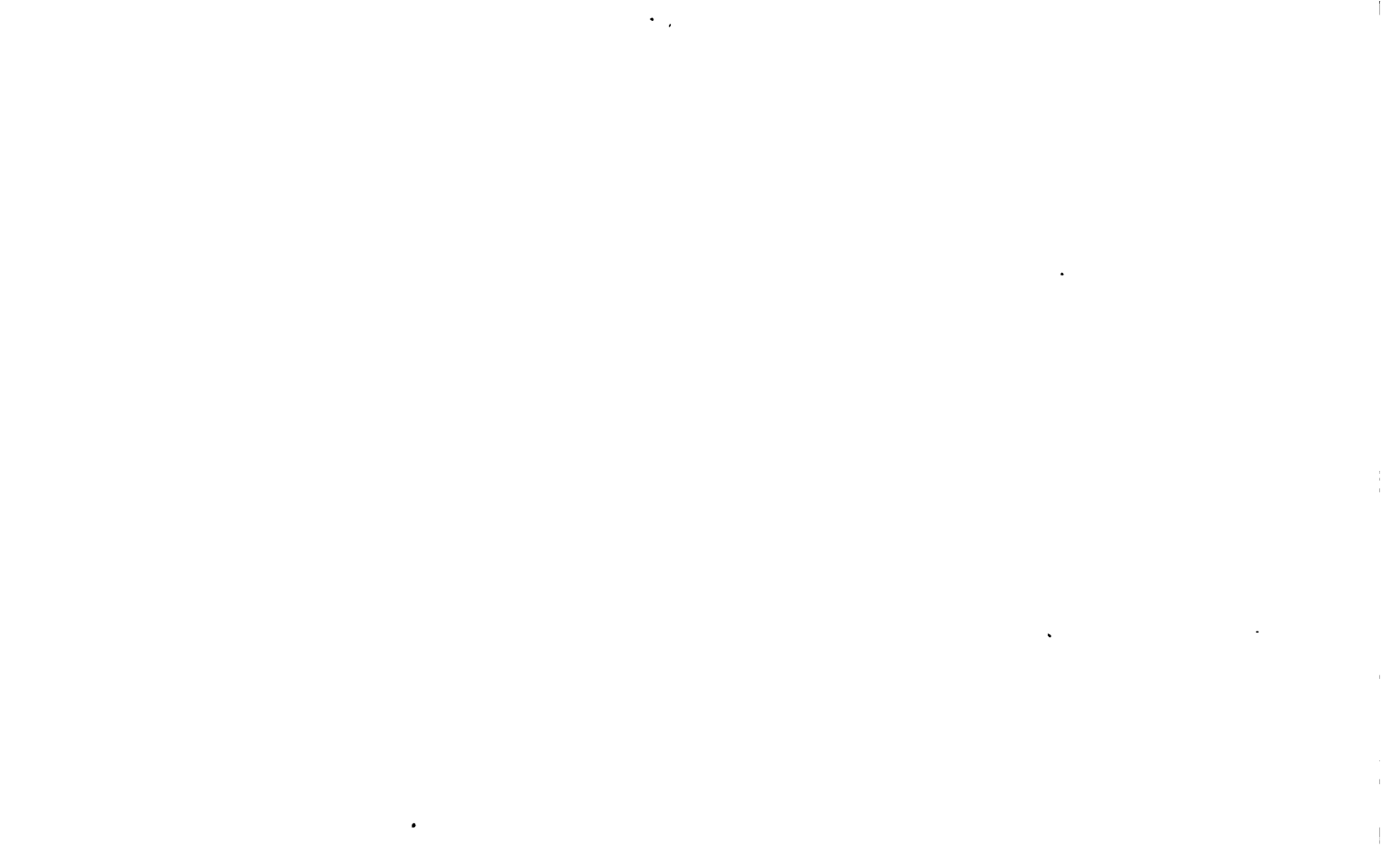


AUTOMATIC TRANSLATION.

21.

*BETWEEN STATIONS WORKING BY INTERMITTENT CURRENT AS PLATES 7 & 8
The Inker records all outgoing Signals. Coils of Inker in Divided circuit. All Distant Stations
must send Zinc currents to Translator and be joined as "Down".*





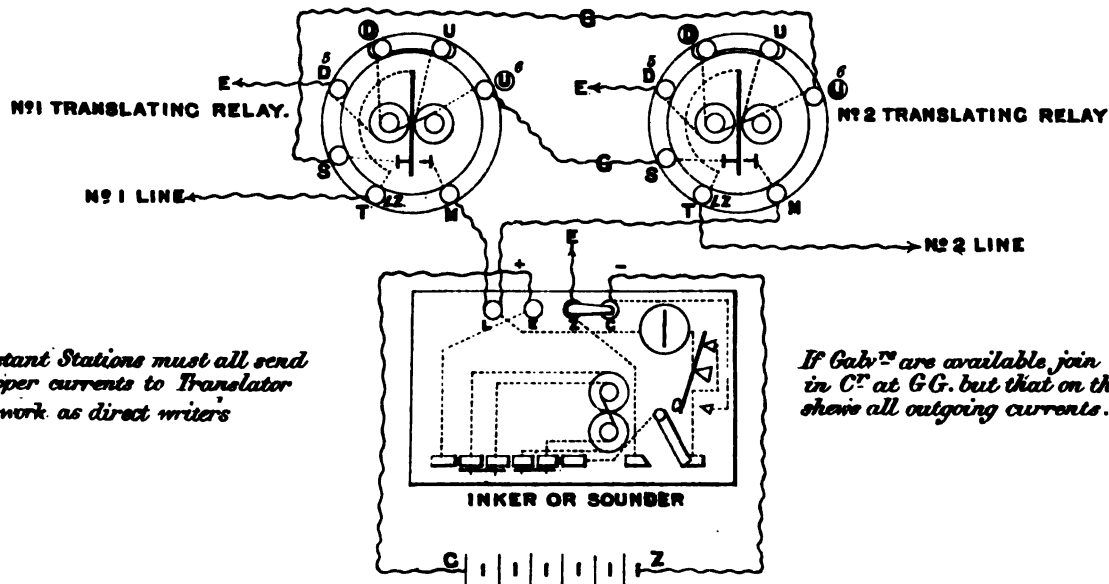
AUTOMATIC TRANSLATION.

BETWEEN STATIONS WORKING BY INTERMITTENT CURRENT AS PLATES 7 & 8.

WHEN SEPARATE KEYS ARE NOT AVAILABLE.

The Inker records all Outgoing Signals; to speak to either of the Distant Stations, adjust tongue of N^o 1 & 2 Relay, respectively to lie hard against M side, & turn bar of Inker to connect terminals labelled Z & E.

The Instruments as shown are arranged for Translation.

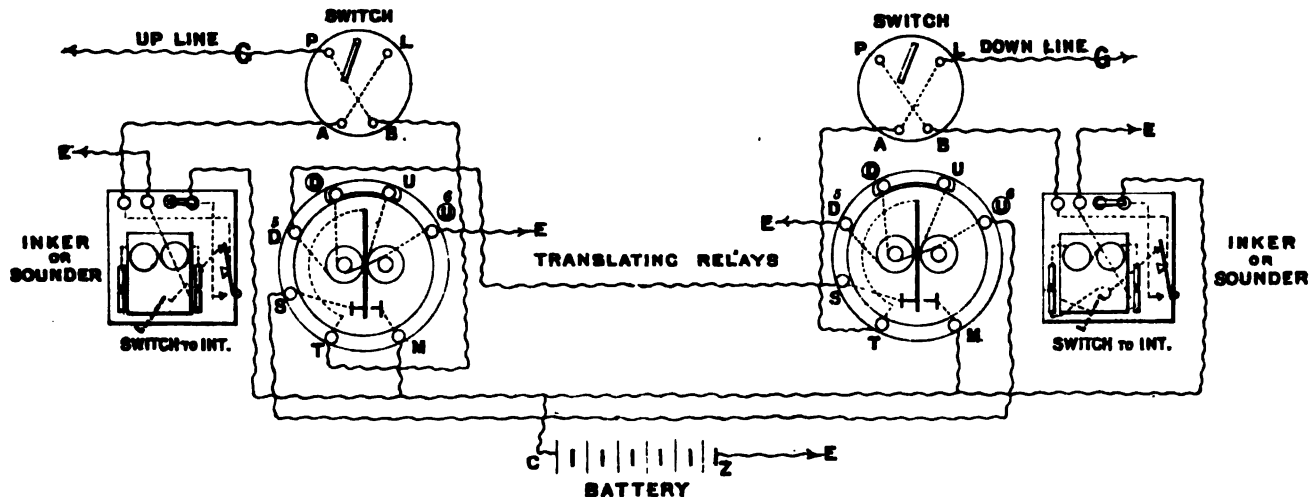




AUTOMATIC TRANSLATION.

FOR CIRCUITS UPON WHICH RELAYS ARE NOT USED.

When Switch Handles are to the Right the Circuit is divided; the Right sounder speaks to the Down, the Left to the Up Stations. The Up distant Station must be so connected as to put Copper to Line & the Down Station Zinc to Line. If Galvanometers are available insert them at G. G.

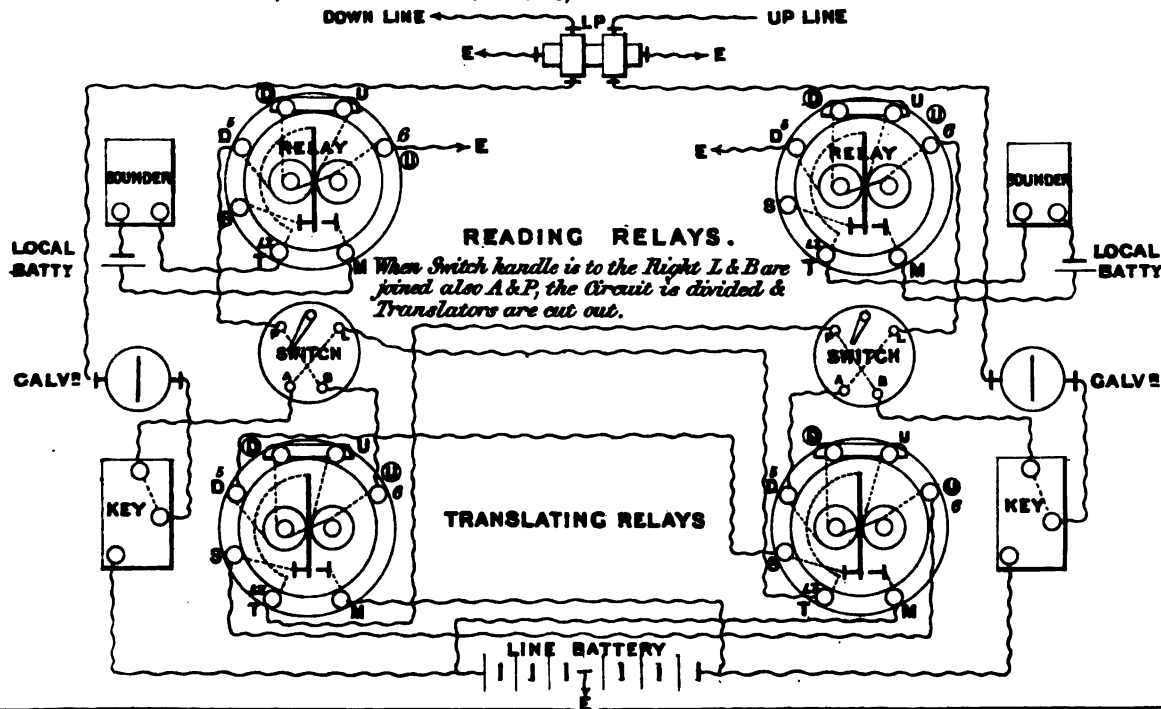


A circuit diagram of a Wheatstone bridge. It consists of four resistors arranged in a diamond shape. The top-left resistor is labeled 'R'. The top-right resistor is labeled 'R'. The bottom-left resistor is labeled 'R'. The bottom-right resistor is labeled 'R'. A galvanometer, represented by a circle with a vertical line through it, is connected between the top and bottom nodes. A variable resistor, represented by a rectangle with a diagonal line through it, is connected between the left and right nodes. The variable resistor is labeled 'R'.

AUTOMATIC TRANSLATION.

25.

*When Switch handles are to Left, keys and relays are all in Circuit; when to Right the Circuit is divided and Reading relays and keys are in position to speak to distant Stations.
All Stations must put C to Down and X to Up Line.*

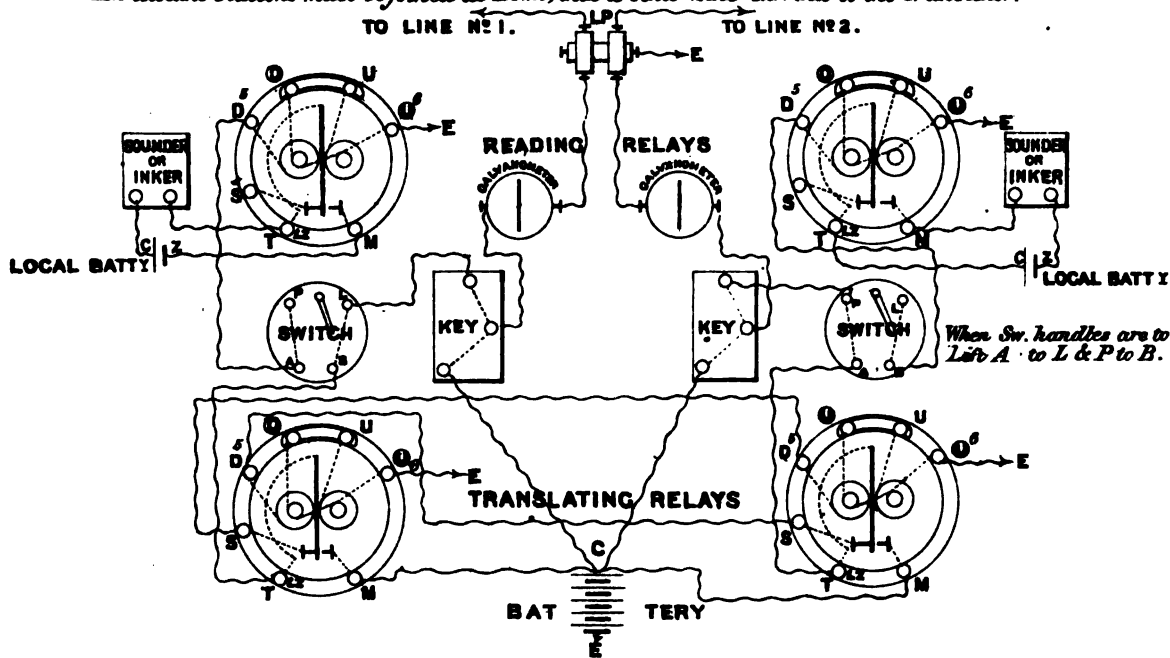


AUTOMATIC TRANSLATION.

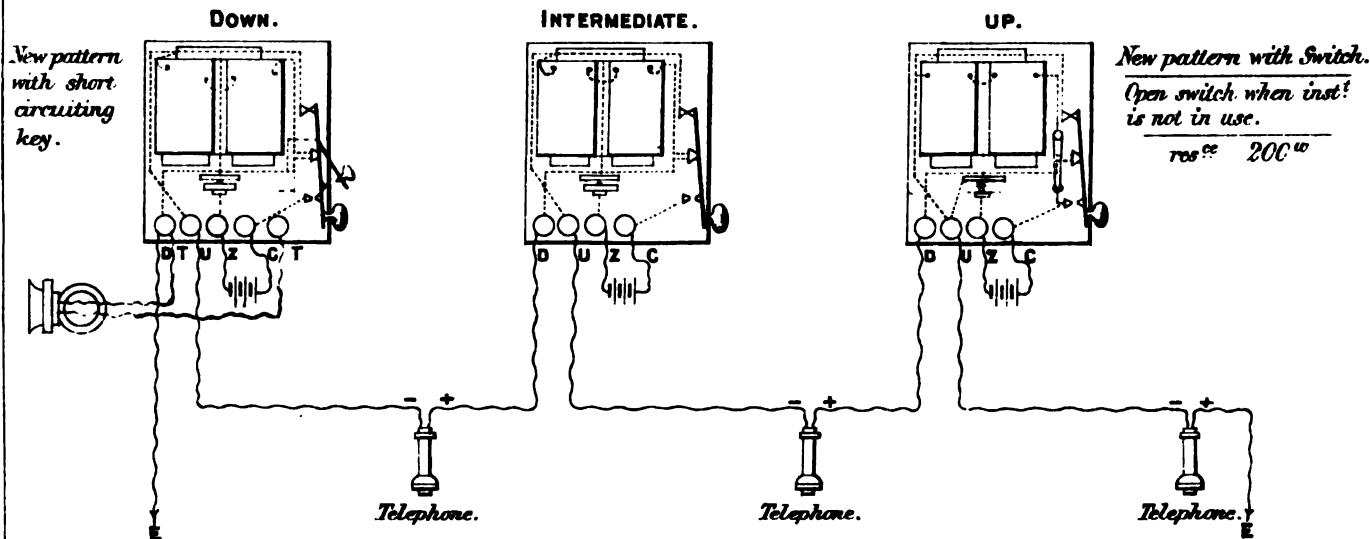
25.

When Switch handles are to Right translating relays are alone in Circuit; when to the Left they are cut out, and Circuit is divided, the Reading relays and Keys are then in position to speak to the distant Stations.

All distant Stations must be joined as Down, that is send Line Currents to the Translator.



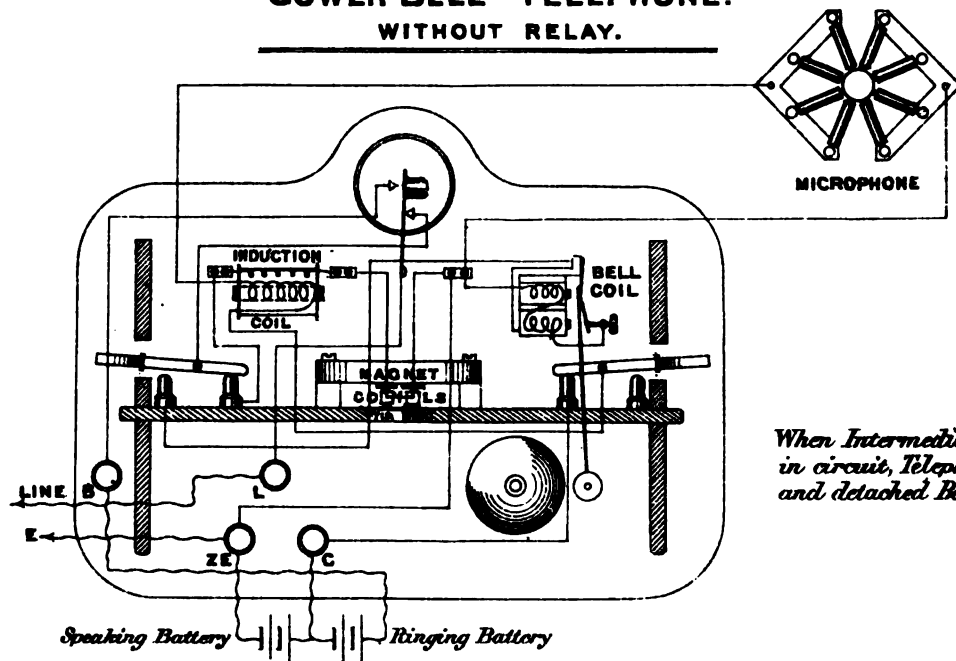
CONNECTIONS OF VIBRATING SOUNDERS & TELEPHONES.



N.B. A Telephone can also be inserted on the down line at each Station if preferred.



GOWER-BELL TELEPHONE. WITHOUT RELAY.



*When Intermediate St^{ns} are
in circuit, Telephones with relays
and detached Bells should be used.*

Only Two or Three Cells are required for Speaking.

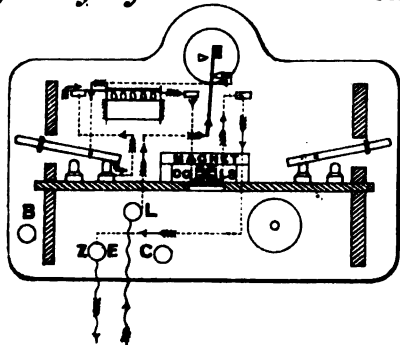


COWER - BELL TELEPHONE.

DIAGRAMS SHOWING COURSES OF CURRENTS.

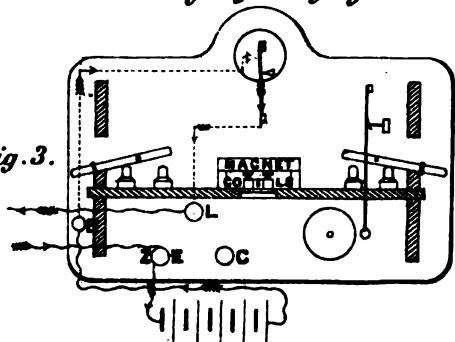
Course of Secondary or Induced Speaking Currents.
Incoming & Outgoing Curr^s follow the same route.

Fig. 1.



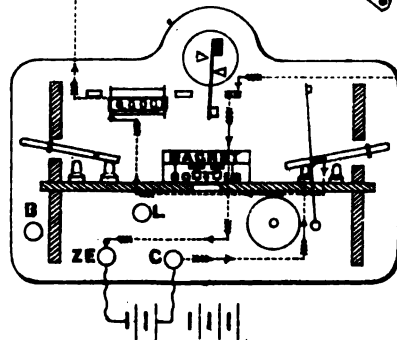
Course of Outgoing Ringing Currents.

Fig. 3.



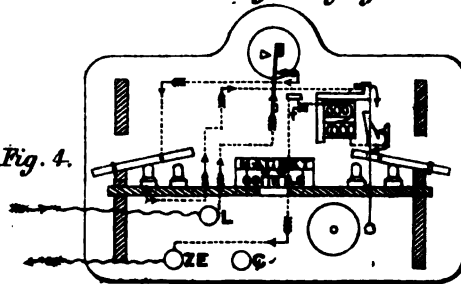
Course of Primary Speaking Current.

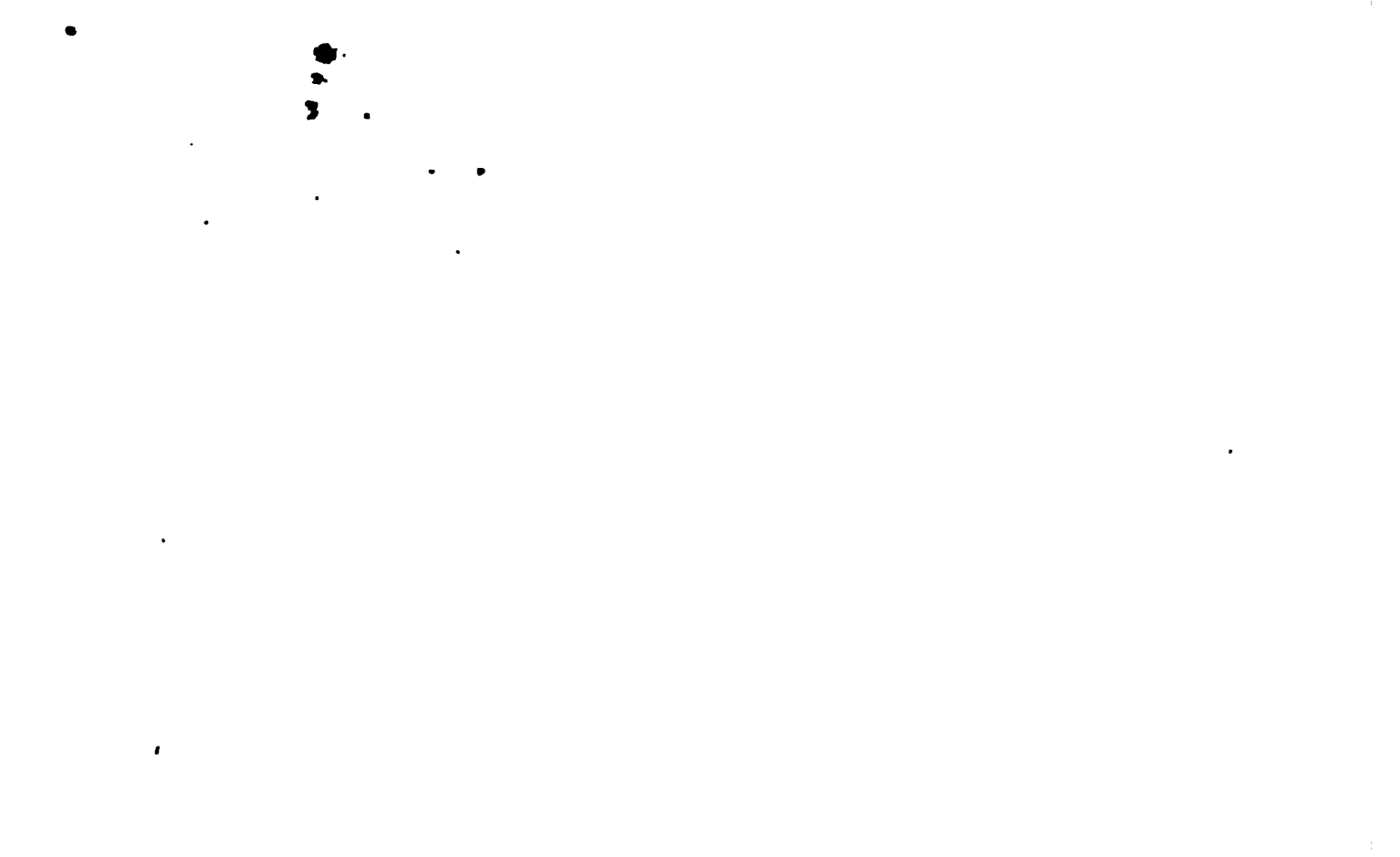
Fig. 2.



Course of Incoming Ringing Currents.

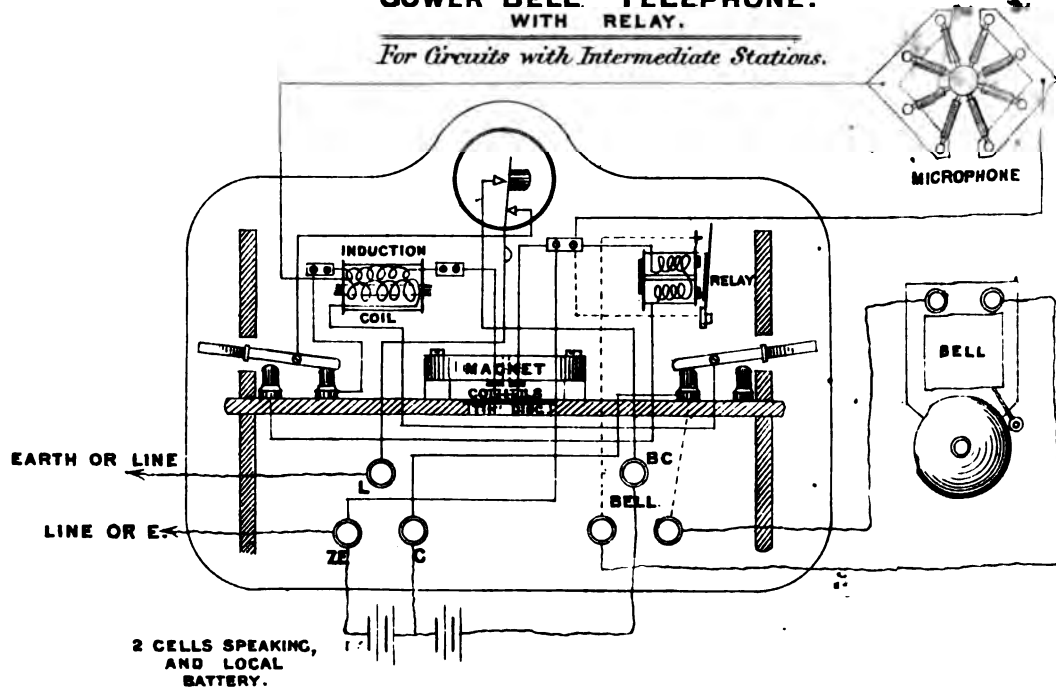
Fig. 4.

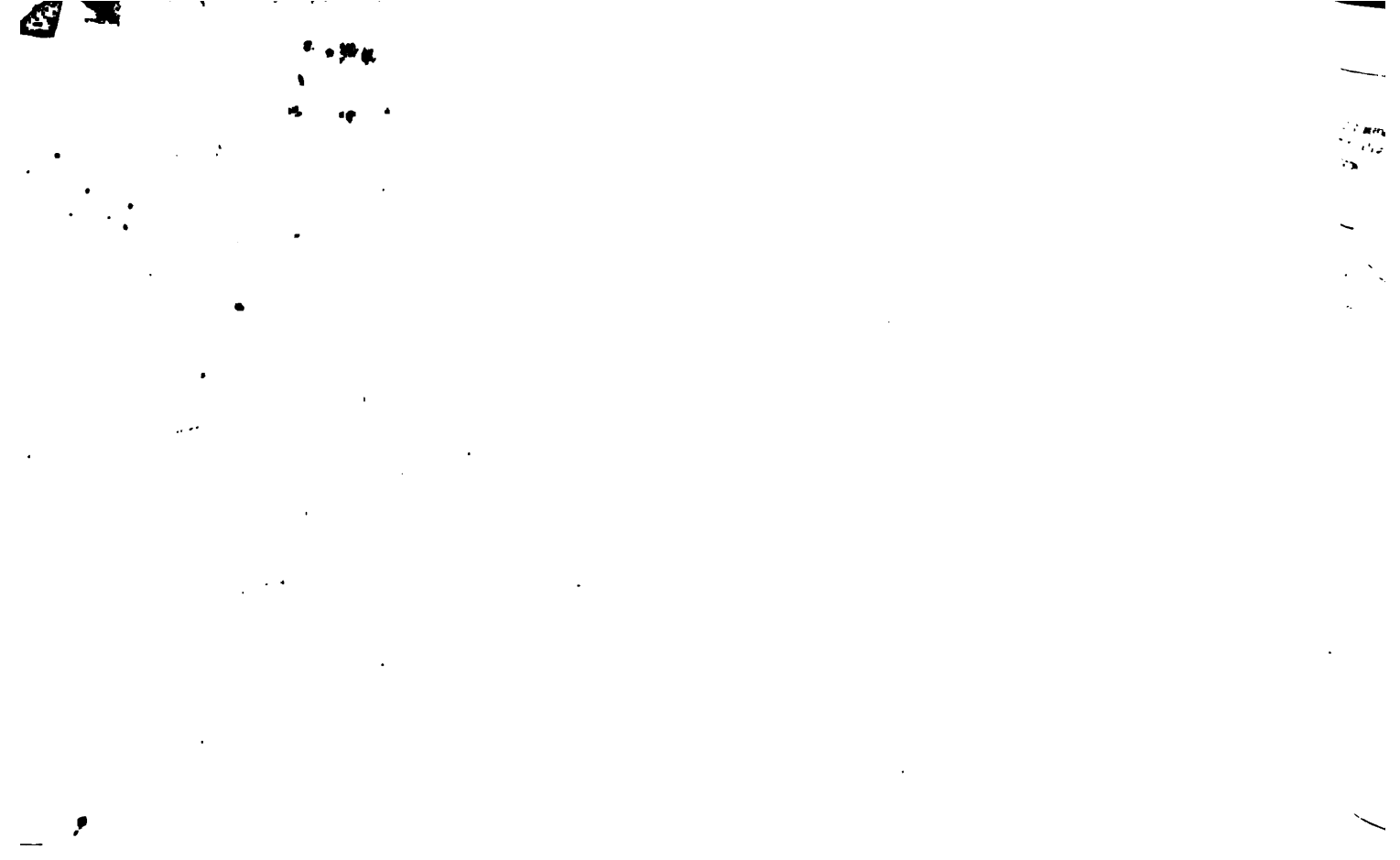




GOWER-BELL TELEPHONE. WITH RELAY.

For Circuits with Intermediate Stations.

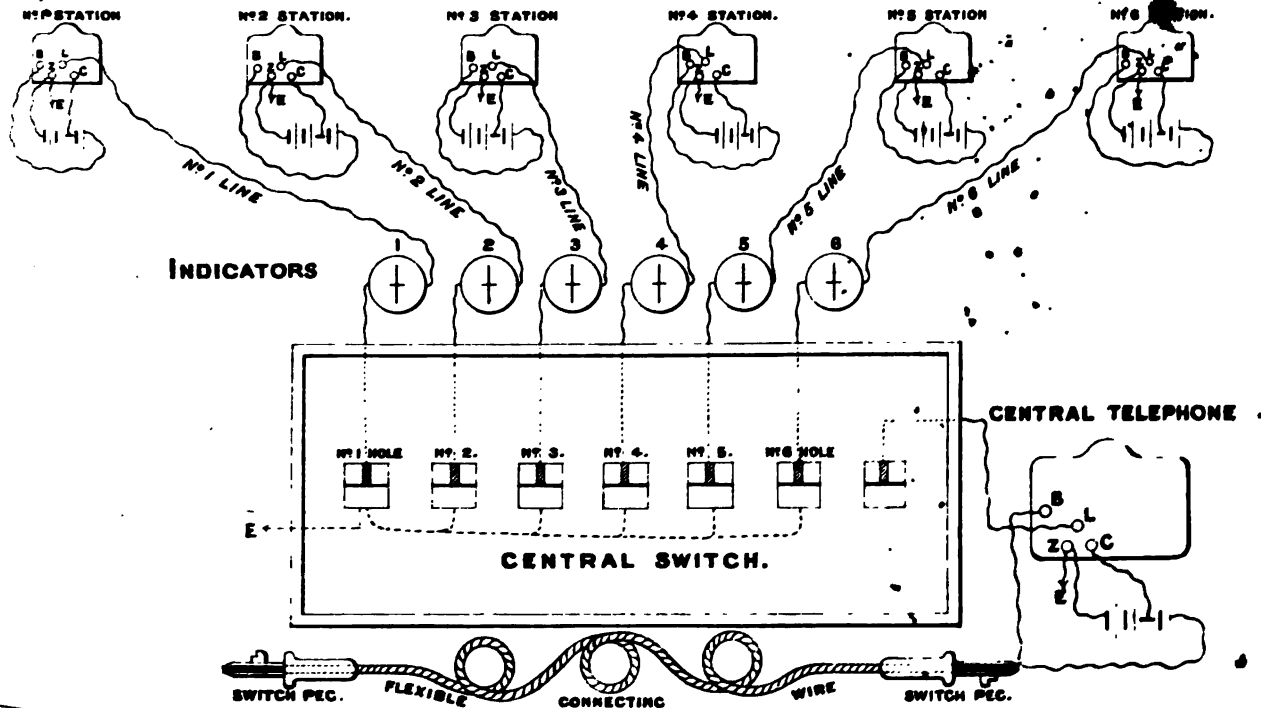


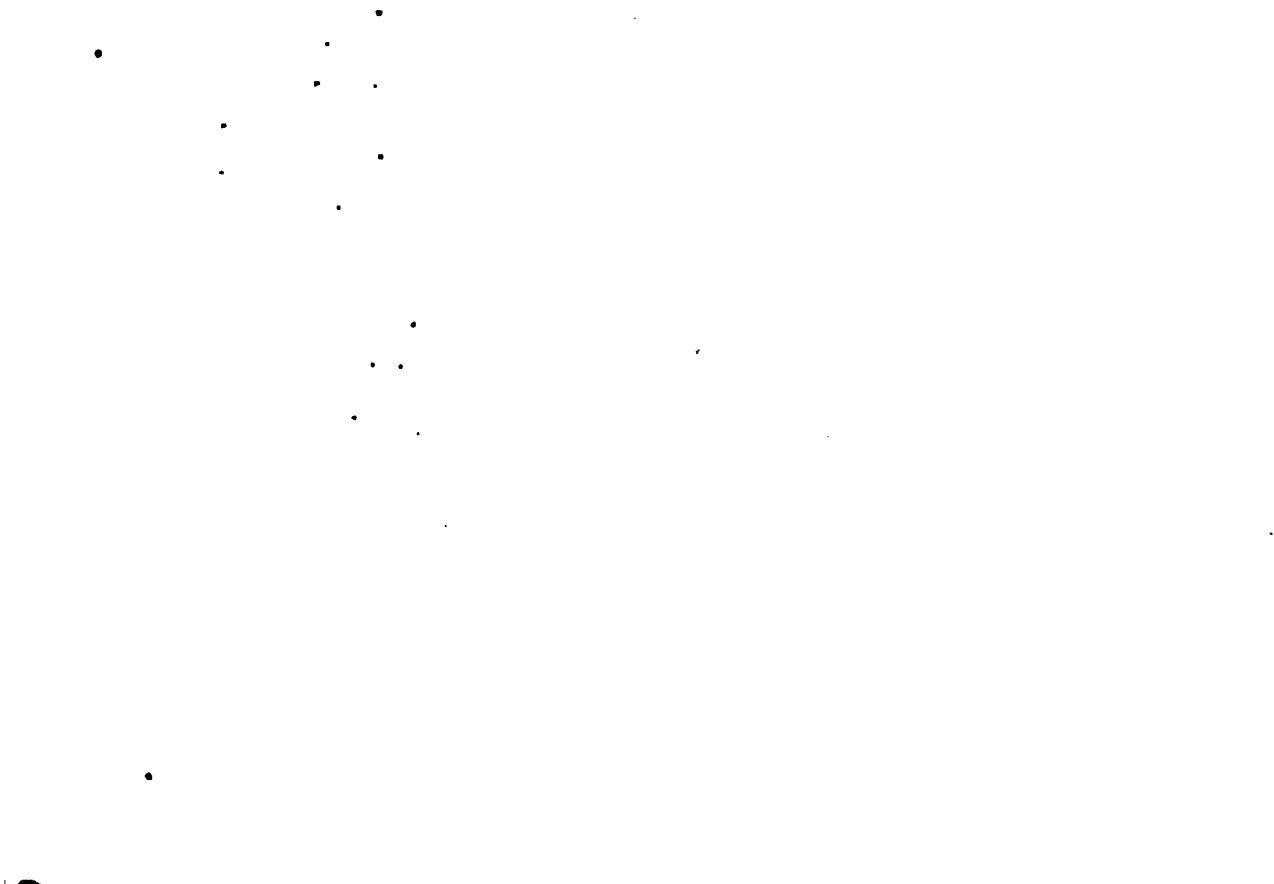


INTERCOMMUNICATION SYSTEM. OR TELEPHONE EXCHANGE.

30.

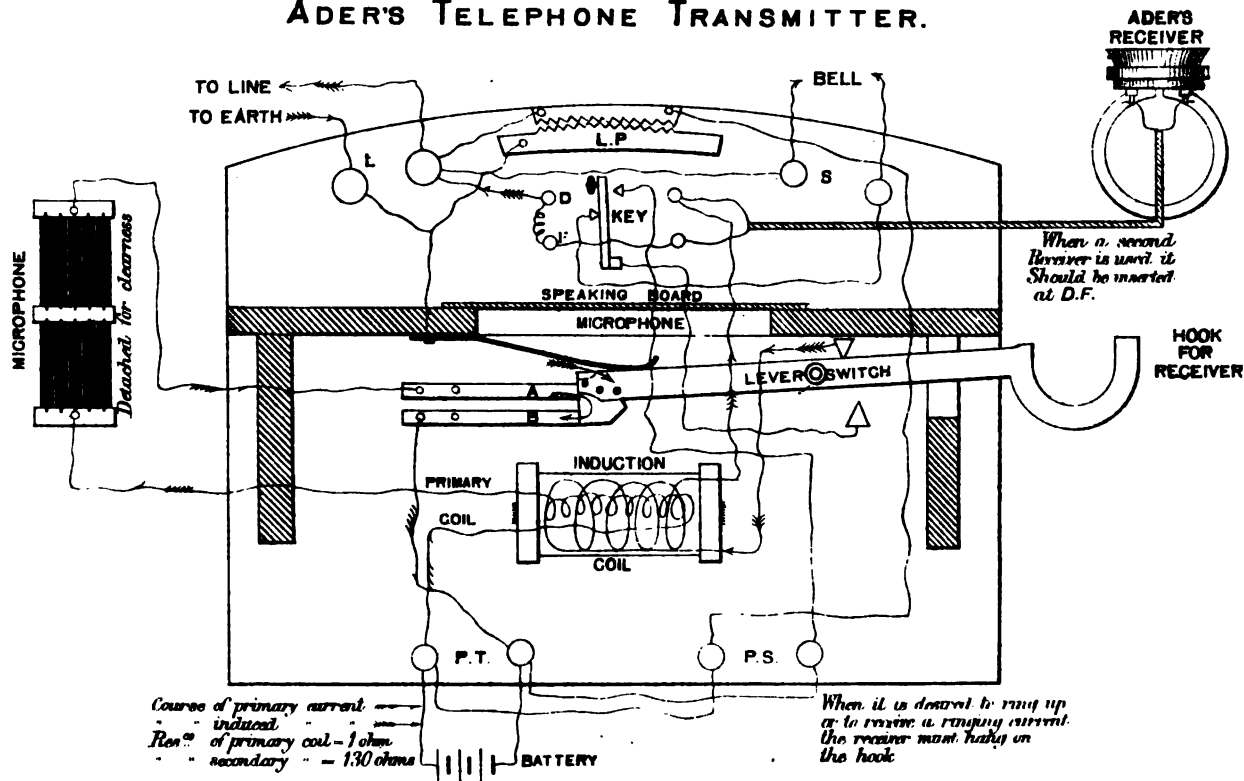
Any Line may be connected with any other or with the Central Telephone by inserting the plugs into the respective holes of the switch. See notes.

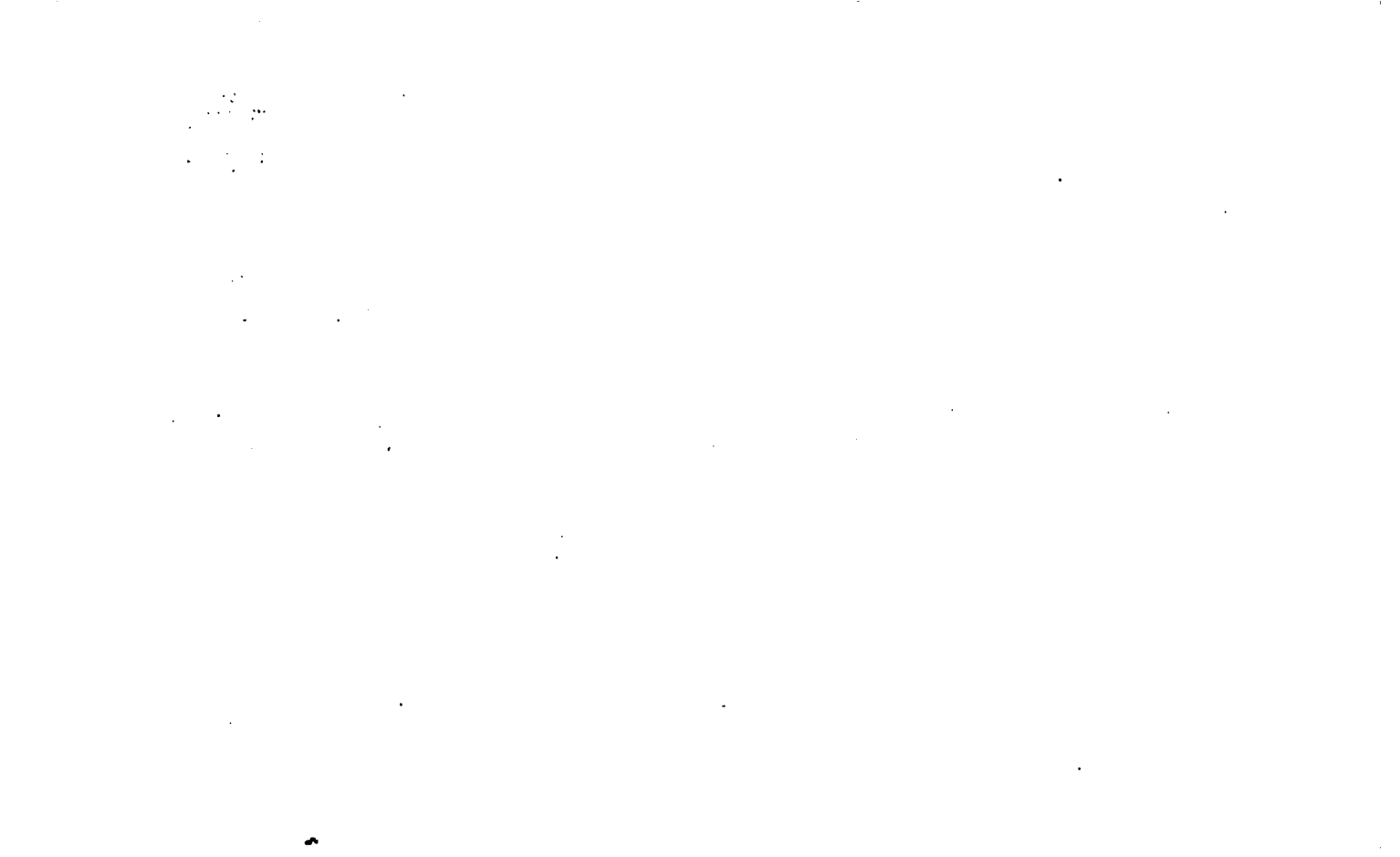




ADER'S TELEPHONE TRANSMITTER.

31.

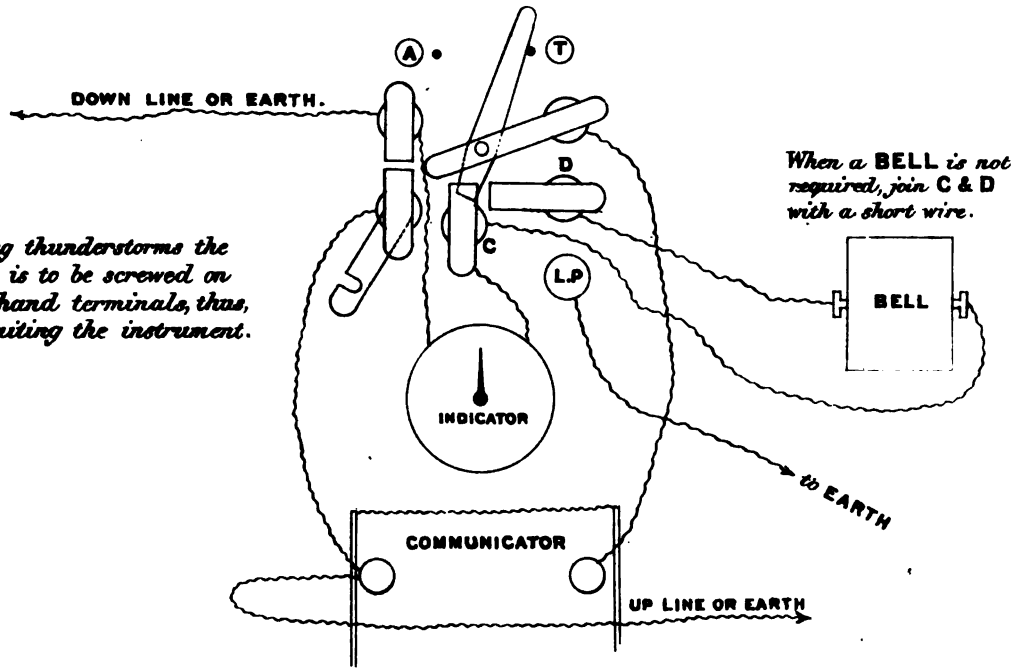




WHEATSTONE'S A.B.C.

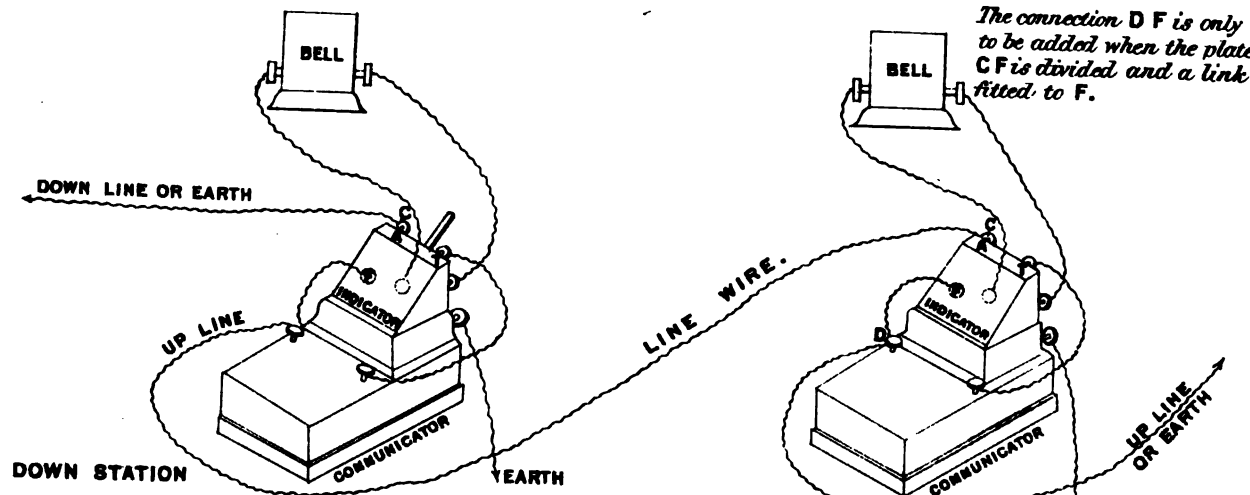
Diagram of connections at back of Indicator.

N.B. During thunderstorms the brass hook is to be screwed on both left hand terminals, thus, short circuiting the instrument.



WHEATSTONE'S A. B. C.

To short circuit, join C.D.



Res. of Communicator	800 ohms
" " Indicator	250 "
" " Bell	250 "
" " Range	7000 "



